MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
DIRECTORATE OF FISHERIES RESEARCH

LABORATORY LEAFLET
NUMBER 63

Cultivation of Pacific Oysters

B. E. Spencer

LOWESTOFT
1990

The author: B. E. Spencer, BSc, is a Senior Scientific Officer at
DFR's Fisheries Laboratory, Benarth Road, Conwy, Gwynedd LL32 8UB

Requests for further information or extra copies of the Leaflet should be addressed to the author.

Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, (63), 47 pp.

CONTENTS

Cont.

Appendices

1. INTRODUCTION

Oysters belong to the commercially important group of bivalve(two-shelled) marine molluscs which also includes mussels, clams, escallops and cockles. In nature, oysters are attached to shells and stones on the bottom of sheltered inshore waters from whence they have been gathered for centuries by man in appreciation of their delicate flavour. Cultivation of oysters was well established by the Romans 2,000 years ago in the Bay of Naples. The history of oyster fishing in Britain, following the Roman withdrawal, is sparsely documented. However, the existence of oyster fishing was recorded by Jacobs (Philpots, 1890) at Faversham, Kent, in 1154 where a company of free dredgers paid an annual royalty to the Crown for their fishing rights. Records show that restraints on fishing were imposed as early as the 16th century when oyster dredging in the Thames estuary was prohibited for several months of the year. In these early times, the fishing on oyster beds was light but, by the late 19th and early 20th centuries, with improved road and rail links to inland towns, fishing pressure increased.

In the past, British oyster beds were to be found in the Thames estuary, along the north coast of Kent at Whitstable, and in the shallow creeks and estuaries of the Rivers Crouch, Roach, Blackwater and Colne along the Essex coast. The oyster cultivated was the European flat oyster (*Ostrea edulis* L.) of which the renowned 'native' oyster was said to have been bred on those beds consisting of London clay.

Of the 22.9 million oysters landed in 1914, 89% were from the east coast, mainly from Brightlingsea and Whitstable, 6% from the south coast, mainly from the Yealm, Helford, Warsash, Fal and Selsey, and 5% from the west coast, mainly from Mumbles and Fleetwood. The east coast fisheries were amongst the richest in Europe in the 18th and 19th centuries. In 1864, almost 500 million oysters were sold at Billingsgate market in London; official statistics for more recent years (MAFF, 1905-1986) however give an average annual landing of 28.4 million oysters during 1903-1914, and 8.9 million during 1975-1985. The decline in landings since the last century has been attributed, by various authors, to overfishing, the failure of spatfalls, disease and severely cold winters.

Traditionally, the flat oyster fisheries in the United Kingdom have been perpetuated by encouraging the settlement of young (spat) by spreading shell (cultch) in the early summer on the sea bed in areas adjacent to mature stocks. This is still practised in some areas of the Solent where, at present, the largest natural flat oyster fishery in the UK is to be found.

During the past 100 years, the American oyster (*Crassostrea virginica* (Gmelin)), and Portuguese oyster (*Crassostrea angulata* (Lamarck)) have provided a lucrative oyster industry in the UK. Half-grown oysters were imported annually from the USA or France and Portugal and relaid, mainly in Essex, for one season to grow and fatten them to market size. Importation of American oysters ceased in 1939 and, following massive mortalities of Portuguese oysters on the Continent in 1966-1970, caused by viral gill disease, the industry in France collapsed and the importation of Portuguese oysters into the UK was banned.

The decline of natural oyster beds, together with a failure of natural spatfalls to replenish stock, stimulated the search for hatchery techniques for the production of oyster seed research under a fully controlled environment at the Fisheries Laboratory, Conwy.

The technology for rearing millions of oysters was developed at Conwy and has been put into commercial practice by privately-owned hatcheries operating from several sites in the UK. Initial interest centred on flat oysters, but the prospect of widening the scope with other species was realised with the introduction, under strict quarantine at Conwy, of the Pacific oyster (Crassostrea gigas, Thunberg) in 1965 and the Manila clam (Tapes philippinarum, Adams and Reeve) in 1980, both from Canada. Trials with Pacific oyster confirmed its fast growth and hardiness in UK waters and it reached market size in 3-4 years compared to 5-6 years for the flat oyster. The recent appearance of the flat oyster disease, Bonamia ostreae (Pichot et al., 1979) , in some parts of the country has reduced the demand for hatchery seed for this species.

Commercial hatcheries now produce up to 100 million juvenile Pacific oysters and Manila clams per year. Many of these are exported to the 'Continent', but Pacific oysters are grown at many sites in our home waters (Figure 1) and now make a significant contribution to shellfish production. Manila clam cultivation is developing slowly but its high

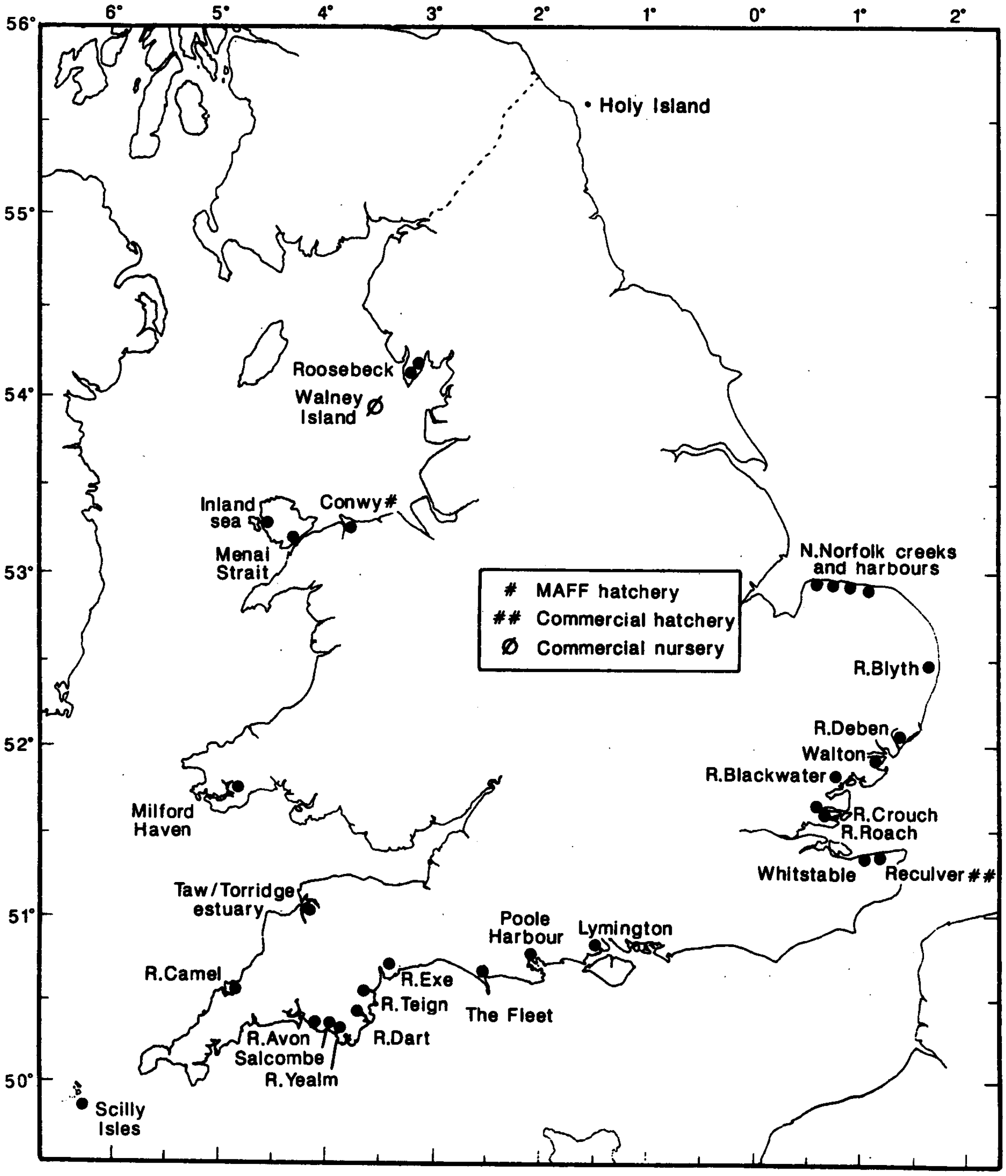


Figure 1 Pacific oyster cultivation sites in England and Wales.

market value and demand on the 'Continent' make it an attractive prospect for the future. Hatchery oysters are sold, usually unattached to cultch, at sizes ranging from 2-3 mm to 10-20 mm. At these sizes, although ready for the sea, they would quickly succumb to the vagaries of the environment and to predation if left unprotected. It has, therefore, been necessary to develop new and economic ways of protecting the hatchery seed to achieve good growth and survival to market size. Consequently, at Conwy, we have examined a number of different systems for growing oysters to a size where they can be safely laid on the ground. Some of these results are summarized here.

Our experience has been gained mainly with trays attached to frames on the foreshore or suspended from rafts; systems readily available to the majority of cultivators. All systems require careful management to ensure the best return for effort. We have not covered every aspect of spat cultivation, since the options available are as varied as man's ingenuity. This manual is based mainly on the culture of Pacific oysters, but some information is provided for flat oysters. It has been gained mostly as a result of experimental work at MAFFS's oysterage in the Menai Strait at Tal-y-foel, Anglesey, Gwynedd, and at other sites around the coast. It has been compiled to assist both the experienced and inexperienced cultivator to obtain consistently good results with their hatchery-reared stock and thus encourage a more rapid revival of the UK oyster industry.

2. NATURAL FACTORS WHICH INFLUENCE THE GROWTH AND SURVIVAL OF OYSTERS

Although oysters may be grown in many sheltered locations around the coast of the British Isles, their growth and survival is influenced by various natural factors. These may be environmental (physical) or biological in origin and are outlined below.

2.1 Environmental factors

2.1.1 Location

The suitability of a range of habitats (sea lochs, estuaries, inshore coastal sites) has been evaluated in different years with trial plantings of oysters in trays. Sites where commercial and experimental Pacific oyster cultivation is in progress (Figure 1) are widely distributed around the coast of England and Wales. Differences in growth between sites (Table 1) usually reflect differences in environment which may be fairly specific to the site e.g. silt load, salinity or sea temperature, but which may vary widely within and between years.

2.1.2 Sea temperature

This has a major effect on the seasonal growth of oysters and is responsible for some of the differences in growth between sites. Growth usually begins in April, reaching a peak in July and August, and declines to a low level by November and December (Figure 2). The seasonal pattern and range of sea temperature is influenced by latitude, water depth, shelter, tidal exchange etc., and it also varies between years and between sites, (Table 2). Shallow creeks and estuaries usually have a higher average summer temperature but a wider daily and seasonal range, than deeper, more stable, bodies of water. The shallow and enclosed waters of the Inland Sea (Anglesey, Gwynedd) warm up rapidly in the spring and early summer to provide excellent nursery growing facilities (Figure 2). At most sites in England and Wales, Pacific oysters should reach market size (75 g) in four years or less. However, in cooler waters, oysters may take an extra year or more to attain this size.

Table 1 Growth and survival of Pacific oysters in trays at various sites in the UK. The trials lasted from April to September (1975) or from April to October (1967, 1978)

Location	Maximum mean monthly temperature (°C)	Pacific oysters	
		Mean weight (g)	Percentage survival
1967		15**	
Highland, Loch Tournaig	13-14	46	95
Strathclyde, Linne Mhuirich	15-16	45	95
Gwynedd, Tal-y-foel	16-17	66	99
Gwynedd, Holyhead	16-17	77	99
Devon, River Yealm	18-19	75	95
Hampshire, Newtown River	18-19	104	100
ØEssex, River Crouch (raft)	18-19	80	100
ØEssex, River Crouch (Althorne Creek)	18-19	77	94
ØEssex, River Roach	18-19	77	93
1975		0.6**	-
Gwynedd, Tal-y-foel	16-17	22.1	95
ØDevon, Kingsbridge	15-16	11.2	88
ØHampshire, Emsworth	17-18	11.0	55
ØEssex, River Roach	18-19	14.4	94
ØEssex, West Mersea	18-19	14.5	100
Norfolk, Brancaster	16-17	32.4	88
1978		0.02**	-
Gwynedd, Tal-y-foel	16-17	5.4	93
Gwynedd, Inland Sea	18-20	4.6	99
Devon, Teignmouth	15-16	7.9	94
Hampshire, Hilsea Lido*	20-22	30.7	98
ØEssex, Goldhanger Creek	18-19	3.1	97

** Initial mean weight
* Stock planted in May, initial weight 0.004 g.
Ø Sites now known to have been affected by TBT poisoning.

Freezing winter temperatures can kill oysters if they are exposed in air for prolonged periods. Submerged oysters have a better chance of survival because sea temperatures are higher than air temperatures in severely cold conditions.

2.1.3 Water movement

Extreme wave action and tidal currents can cause physical damage to oyster growing installations or to the oysters themselves. Sheltered areas with tidal flows of up to 1-2 knots (50-100 cm per second) provide the best conditions. However, tray cultivation can be successful in water of minimal flow (e.g. Inland Sea where gentle wave action and rise and fall of tide are the only means of providing adequate exchange of water over the oysters). At more exposed sites (e.g. Morecambe Bay), robust installations are necessary to withstand the extra buffeting by the waves.

Table 2 Mean monthly sea water temperatures (°C) at selected sites in the UK

	J	F	M	A	M	J	J	A	S	O	N	D
Loch Spelve (Mull)	7.7	7.0	6.6	7.3	8.4	9.9	11.2	12.2	12.2	11.8	10.6	9.2
Loch Sween	6.2	6.3	6.6	7.6	9.5	11.3	12.5	14.2	13.6	12.1	9.3	8.0
Loch Mhuirich	6.7	-	-	7.4	10.5	13.0	16.0	16.1	15.6	13.2	9.8	7.8
Brancaster	4.5	4.2	5.8	8.4	11.6	15.2	17.2	17.9	15.4	11.9	8.3	5.7
River Crouch	-	-	4.9	8.2	12.5	16.3	18.8	18.5	16.2	12.5	7.5	4.8
Poole	5.6	5.2	6.3	8.5	12.4	15.8	18.1	18.0	15.8	12.6	9.0	6.5
Teignmouth	8.0	7.8	8.0	8.8	11.2	13.7	16.2	16.7	16.2	13.7	11.3	9.6
Milford Haven	-	-	-	8.1	11.0	14.1	15.4	16.2	16.0	14.5	13.0	-
Menai Strait	6.7	6.0	6.6	8.2	10.9	13.7	15.8	16.6	15.2	12.6	9.9	7.6
Inland Sea (Anglesey)	4.8	4.5	7.3	9.5	14.6	15.8	15.9	16.2	14.1	12.7	10.5	-

Data from various sources. Teignmouth from Teignmouth Borough Council: Milford Haven from Central Electricity Generating Board; Menai Strait from Marine Science Laboratory, Menai Bridge: Scottish sites from Milne (1972). Other sites from MAFF records.

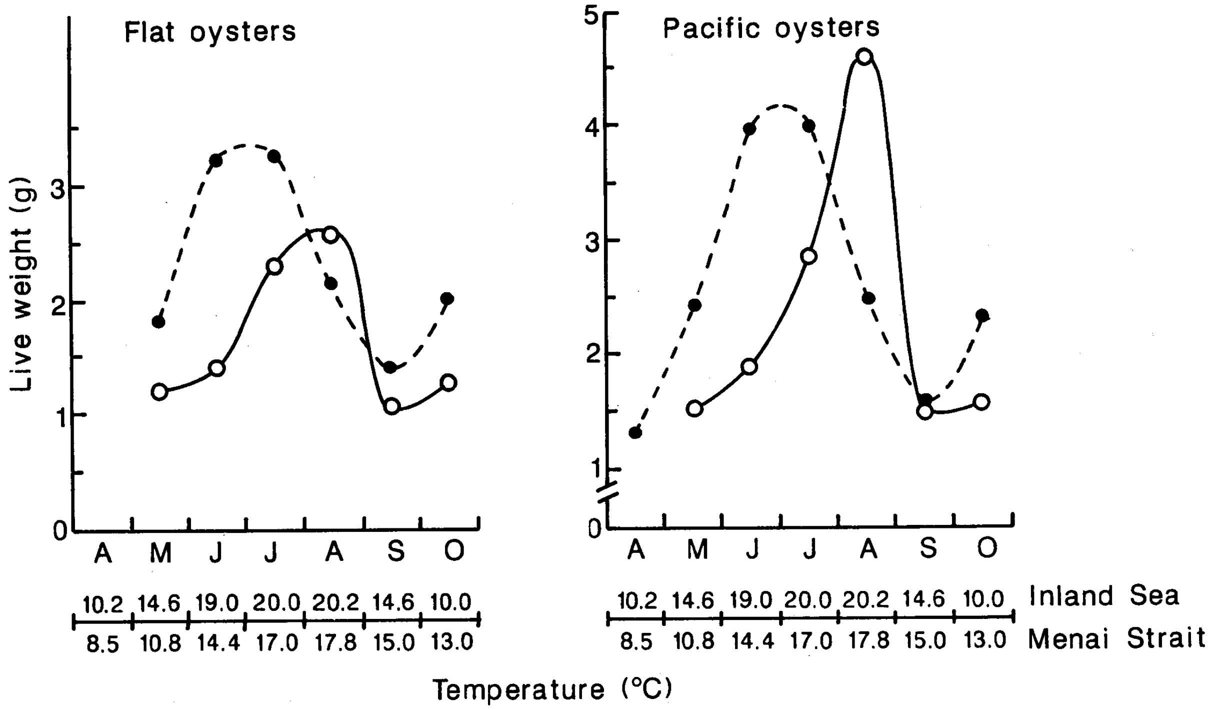


Figure 2 Seasonal growth of 1 g Pacific oysters and flat oysters at the Inland Sea (•) and Menai Strait (o) in 1976.

Table 3 Growth of Pacific oysters at various levels of intertidal exposure. Growth, after one season, is expressed as a percentage increment of that at full immersion. Data are for oysters in trays in Menai Strait and River Roach (Spencer *et al.*, 1978)

Percentage exposure to air	Percentage growth increment
0	100
8	75
18	50
26	25
34	0

2.1.4 Exposure to air

Oyster growth is strongly influenced by the length of time during which the oysters are submerged by the tide and, therefore, feeding. Young oysters cultured on the foreshore should be kept as near as possible to low water of spring tides to ensure nearly 100% immersion. Growth stops when oysters in trays are exposed to air for more than 35% of the time (Table 3). This fact, however, can be used to advantage by the cultivator who may wish, for commercial reasons, to slow down or temporarily stop the growth of his stock by moving it higher up the beach. He can do this with confidence during the summer without fear of causing undue mortalities or reducing the meat quality of his oysters. This practice is routinely adopted in Korea and Japan for "hardening off" wild-caught spat prior to sale.

2.1.5 Siltation

Trays, particularly those with small mesh, may quickly clog with silt. This can smother the oysters or cause them to grow more slowly because of the poor exchange of water. Areas vary considerably in the silt content of their waters, but those with high silt loads can be used successfully for cultivation providing trays are serviced regularly. In very turbid waters (e.g. River Roach and West Mersea), trays may need cleaning every two weeks.

2.1.6 Salinity

Open coastal areas are usually fully saline with small seasonal variations of between 30 and 35 practical salinity units (psu). Estuaries have a daily input of freshwater and, consequently, have a continually varying salinity pattern with values ranging from zero (freshwater) to about 35 psu, depending on their proximity to the sea, state of the tide, and rainfall. Although oysters grow well at a wide range of salinities, flat oysters prefer higher levels near to 30 psu and Pacific oysters prefer lower levels near to 25 psu.

2.1.7 Oxygen

The oxygen content of sea water is usually sufficiently high for oysters to respire normally. In some circumstances, however, (e.g. in hot, calm weather during low water periods of neap tides) oxygen in sea water may become depleted. This can stress the oysters causing them to gape and possibly to die. These periods are usually of short duration and the danger passes before remedial action, such as reducing stock density or moving stock to suitable waters, can be taken.

2.1.8 Pollution

Waters contaminated with heavy industrial pollution (e.g. heavy metals, and organic compounds) are unsuitable for oyster culture. Similarly, areas receiving untreated sewage should be avoided because of their high organic load and potential pathogenic virus content; faecal bacterial content is not a problem with young oysters but edible stock must be purified in cleansing tanks (Ayres, 1978; West, 1986) before sale for consumption. Some areas naturally contain high levels of heavy metals, (e.g. copper and zinc), washed out from disused mine workings and geological strata. These metals accumulate in the flesh without harming the oyster but may render it unpalatable due to its unpleasant flavour. Copper tainting, for example, has been reported from some areas of the Fal, Tamar, and Lynher (Cole, 1956) but this type of contamination and others, such as oil taint, can be removed by relaying stock in unpolluted waters for several months.

During the 1970's and early 1980's, growth of Pacific oysters in many areas with high concentrations of small boats was severely affected by the presence of tributyl tin (TBT) in the water. The presence of this chemical, a component of antifouling paints, caused severe thickening of the shell and stunted growth with this species of oyster. Since July 1987, the use of TBT-based paints on small, inshore vessels, has been banned. Some of the sites tested in 1975 (Table 1) are now known to have been affected by TBT.

2.1.9 Exceptionally adverse conditions

An initial well-prepared site survey should eliminate those sites which are likely to suffer from extremes of any of the factors described above. Application to MAFF Fisheries Laboratories, or Inspectorate Offices, Sea Fisheries Committees (See Appendix 1), Public Health Laboratories, Local Authorities, and Harbour Boards will often provide information on water temperature, salinity, pollution, previous history of oyster cultivation, etc. Nevertheless, it is wise to supplement such knowledge with trial plantings of oysters before starting a major enterprise. The exceptional losses which occur very infrequently (for example due to flooding, storm damage, severe winters, major oil pollution, etc.) are difficult to anticipate but insurance against such losses is possible now that aquaculture is recognised as an insurable risk.

2.2 Biological factors

Plants and animals in their roles as food species, predators, competitors, or fouling organisms also greatly influence the growth and survival of oysters as shown below.

2.2.1 Food

Oysters feed by filtering microscopic algae (phytoplankton) and organic detritus from sea water. An adult oyster may pump up to ten litres (2.2 gallons) of sea water per hour through its body cavity, depending on its size, sea temperature and other environmental and biological factors. The value of naturally-occurring food is impossible to evaluate by inspection of water samples, since seasonal abundance and quality of microalgae fluctuate widely. Normally, however, peak abundance of phytoplankton occurs in the spring with a lower peak in the autumn. Coastal and estuarine waters generally have sufficient food in relation to prevailing temperature to support reasonable growth. Blooms of unsuitable algae may also occur, usually in response to a combination of certain environmental conditions, and these algae are often nutritionally unsuitable and, consequently may reduce the growth of oysters.

Some microscopic algae produce toxins which accumulate in the flesh of mussels, oysters and clams. Dinoflagellates, belonging mainly to the genus *Gonyaulax* (*Alexandrium*), are frequently implicated. Shellfish containing the toxin can induce paralytic shellfish poisoning (PSP) in humans who eat them. The toxin is not denatured by cooking nor eliminated by cleansing the shellfish in purification tanks. Fortunately, the incidence of occurrence of PSP in the UK is low. The north-east coast of England and some areas of the east and west coasts of Scotland are most frequently associated with the occurrence of toxic dinoflagellate blooms. Mussels from these areas are tested regularly during spring and summer. If the level of toxin exceeds a safe threshold, the collection of shellfish for consumption is prohibited until the levels are safe. The last notable outbreaks of PSP in the UK occurred in 1968 and 1990.

2.2.2 Predators

Unprotected oysters and other small bivalves are eaten by various predators, especially shore crabs, drills or tingles, starfish (Hancock, 1969) and, to a lesser extent, by birds.

The shore crab (*Carcinus maenas* L.) is the most abundant and widespread predator in estuaries and coastal sites and has a most voracious appetite for young bivalves, which it eats after cracking open the shells. The largest crabs (over 65 mm wide) can eat oysters up to about 10 g but, since crabs of this size are relatively scarce, oysters larger than 10 g may be considered to be crab-proof. The abundance of shore crabs on the foreshore may not be obvious because of their habit of advancing up the shore on the flood tide and retreating into deeper water or hiding on the ebb.

Oyster drills or tingles are marine snails which eat bivalves by rasping a hole through the shell to gain access to the flesh. The distribution of these pests is fairly limited, with the American whelk tingle (*Urosalpinx cinerea* Say) centred around the Thames estuary in Essex and Kent, and the European rough tingle (*Ocenebra erinacea* L.) occurring on some of the important oyster grounds of the Fal, Helford River, Solent and estuaries of the east and south coast. Hancock (1954) reported that 58% of an oyster spatfall in the River Crouch was devoured by the American whelk tingle, while Key and Davidson (1981) noted that in 1978 *Ocenebra* killed 11% of 30-45 mm flat oysters, laid on the sea bed in a plastic mesh container in Southampton Water for two months in the summer. However, in recent years tingle abundance in some areas has probably been reduced by the presence of TBT in the water. Following the ban on the use of TBT, its concentration in the environment will continue to diminish and tingle are likely to re-emerge again as important predators in the future.

The common starfish or "five fingers" (Asterias rubens L.) can attack and eat oysters by pulling the shells slightly apart and digesting the flesh *in situ*. It is considered to be a minor pest of oysters, however, since starfish are restricted to high salinity areas, usually in the sublittoral zone, and prefer to eat mussels and slipper limpets which themselves are competitors of oysters (Hancock, 1955).

2.2.3 Competitors

Established oyster grounds have suffered from the effect of slipper limpets (Crepidula fornicata L.) which compete with the oysters for food and space and, in silty waters, also produce a muddy substrate which is unsuitable for oyster cultivation (Hancock 1969). The slipper limpet was introduced accidentally into this country with imported oysters from America in about 1880 and has now spread around our coast to most oyster producing areas. Walne (1956) estimated that 1150 tonnes of slipper limpets inhabited a five-mile stretch of the River Crouch, Essex, or about ten times the weight of oysters in that area. Since mechanical dredging and disposal is the main means of control, the costs of reclamation of grounds are likely to be high. However, in the Solent, the presence of slipper limpets benefits the fishery by providing an abundant supply of cultch for the settlement of oyster spat.

2.2.4 Fouling organisms

Fouling is a general term used in aquaculture to describe animals and plants which attach themselves to immersed equipment and to oysters. The type and degree of fouling varies with locality and its main effects are to reduce the flow of water and food to oysters in trays and to increase the weight and drag on floating installations. Green filamentous seaweeds can be controlled by spraying with dilute copper sulphate solution (10% w/v), followed by exposure to air for one hour. However, such antifouling compounds are toxic and it is better to adopt the less harmful practice of pressure hosing, or to turn the bags over frequently. Individual or colonial sea squirts can be killed, without harming the oysters, by immersion in saturated brine solution for 5-10 minutes followed by exposure to air for one hour. Barnacle and worm encrustations are not usually a problem on oysters but they can be removed from empty containers - using high pressure (2000 pounds per square inch) water sprays, or by leaving the containers ashore for several months. Barnacles can be crushed using a garden roller if the bag is sufficiently flexible, while immersing plastic trays in hot water is effective but costly. Mussel spat may also settle in oyster trays and removing them can cause the cultivator extra work. Large settlements of mussels create competition for food and space whereas sparse settlements cause localised clumping of oysters which become bound together by mussel byssal threads. The addition of a few dogwhelks (Nucella lapillus), which preferentially prey on small mussels, may help to control this problem (Minchin and Duggan, 1989).

3. CULTIVATION: PROCEDURES AND PRINCIPLES

Although official statistics show that natural flat oyster fisheries still remain the major UK source of oysters, by value and tonnage, Pacific oysters are beginning to make a significant contribution to production and are seen as a means of redeveloping a more broadly-based industry around much of the coast. This section provides information on some aspects of cultivation and husbandry which will be required by the hatchery-seed purchaser to achieve good growth and survival of his stock.

3.1 Hatchery seed

3.1.1 Sources

Oysters may be bought from commercial hatcheries and nurseries (Appendix 1) in which hatchery-reared stock have been grown to a larger size. The usual range of sizes offered for sale are 3 mm to 30 mm (0.005 g to 3 g) at prices ranging from £6.50 to £30 per thousand depending on size (1990 price list).

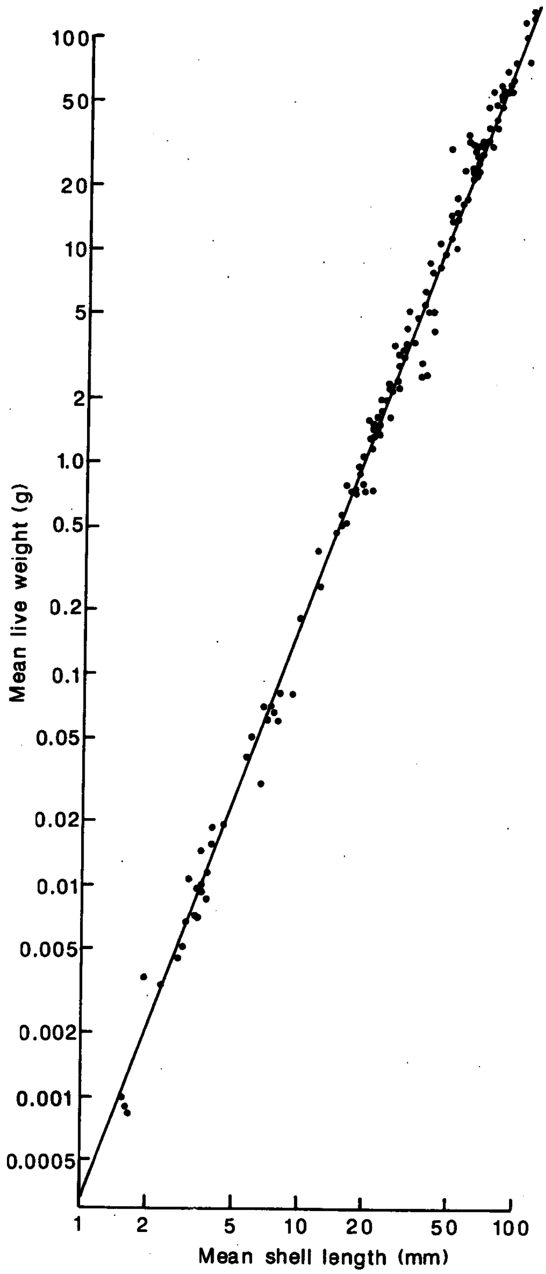


Figure 3 The relationship between shell length and live weight of Pacific oysters.

3.1.2 Sizes

Commercial suppliers refer to oyster size by the length of the shell, and often sell seed graded to sit on a particular mesh size. Commonly used sizes of mesh in tray construction are 2 mm, 5 mm, 9 mm and 18 mm with those dimensions referring to the length of one side of square mesh aperture. Other, intermediate, mesh sizes are available from some manufacturers.

To ensure that all of the population is retained, the oysters are sieved onto a mesh 30-50% larger than that used on the tray. When measuring oysters, it is simpler to count and weigh a sample than to measure shell length. Thus, oyster size in this leaflet is usually expressed as the average live weight in grams (g) or milligrams (mg = 1/1000 g). Figure 3 shows the relationship between shell length (longest axis) and live weight for Pacific oysters; the relationship for flat oysters is similar.

3.1.3 Quality

Spat quality is judged by the capacity of the spat to survive and grow well. This depends largely on the early welfare of the spat in the hatchery and may vary considerably between batches, months or years. It is difficult to estimate visually or quantitatively but, on receipt, the seed should be tightly closed and contain a low proportion of dead or empty shell. A reputable supplier may replace seed which shows high mortality shortly after relaying, so long as he is satisfied that it has been treated carefully by the purchaser.

MAFF plantings of Conwy-reared Pacific oyster seed, smaller than 8 mm, in experimental trays in the Menai Strait, in 1973-1977, showed that survival after 6 months averaged 77% (3-4% mortality per month). The percentage of batches with different survival rates was as follows:

% of batches	Average % survival after 6 months
82	89
11	52
6	33
2	14

With careful handling, a high proportion of batches should show good survival. Survival of flat oysters is usually lower than that of Pacific oysters. From 1978 to 1981, thirty-two samples of flat oysters, from six batches reared at Conwy and planted in trays at seven sites, had an average monthly mortality of 8% (range 3% to 15%) which is two to three times higher than that for Pacific oysters.

Although spat survival improves with increasing size, there is no ideal size for the purchase of seed. Much depends on the experience, equipment, strategy and effort of the cultivator. The higher initial cost of larger seed must be judged against the improved yield and eventual savings in labour and equipment costs. As a general guide, a cultivator may expect 70% survival of Pacific oysters in the first year and, thereafter, 90% per year to market size using careful tray cultivation practice.

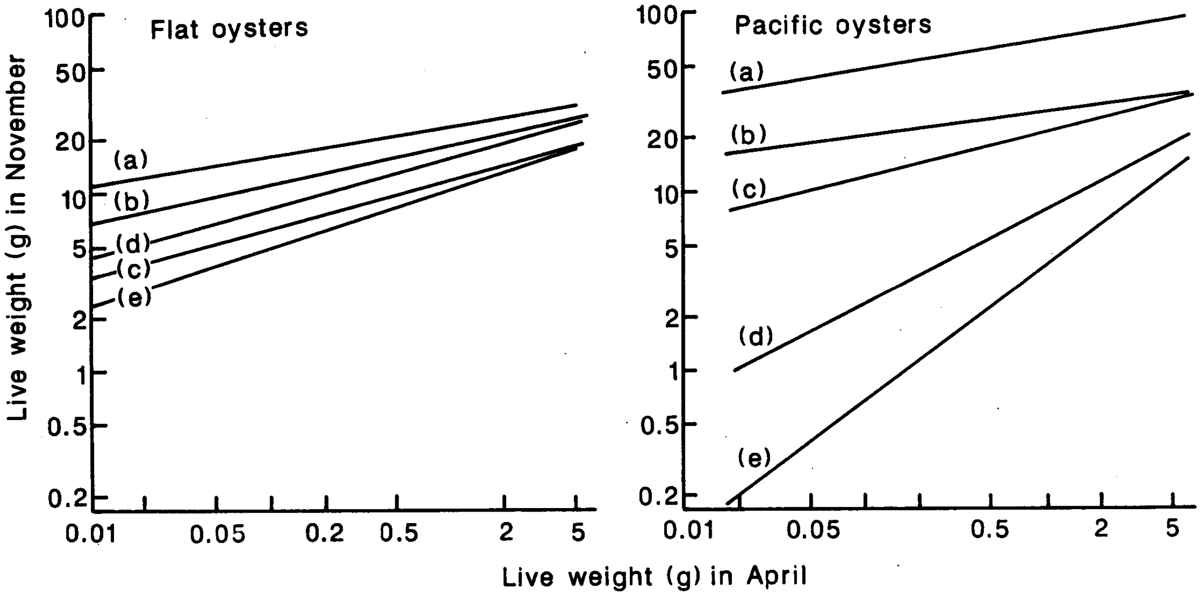


Figure 4 Growth of flat oyster and Pacific oyster seed in trays at five sites in England and Wales in 1982.

3.1.4 Planting season

Seed may be planted successfully in trays in any month from April to September (see also Appendix 2). The cultivator should recognise that there is some risk in planting during October to March with success depending largely on climatic conditions and site.

At low tray densities, 0.5 g (15 mm) Pacific oysters bought in the spring should grow to 10-20 g by the end of their first season and 50 g in their second season. However, 0.01 g (3-4 mm) oysters planted in July should grow to 1-5 g in their first season and probably will not reach 50 g until their third season. At high stocking rates and with less frequent servicing schedules, growth to market size may be prolonged by an extra year or more.

The growth potential of Pacific oysters of various sizes varies with site (Figure 4). For example, in 1982, one season's growth of 1 g oysters ranged from 4 g to 70 g depending on site. The two poorer sites are now known to have been areas affected by TBT contamination. The best site was a disused quarry which benefited from high summer temperatures and an abundance of food. Site differences were less pronounced with the flat oyster because of its slower growth and higher tolerance to TBT.

3.2 Systems and materials

Hatchery- or nursery-reared oysters require some form of protection until they reach about 10 g in size. Unprotected juveniles are vulnerable to predation, mainly by shore crabs, to strong tidal and wave action and to siltation. The effects of these hazards can be minimised by a variety of methods of cultivation which enable the cultivator to safeguard his stock through the critical early life stages. The following flow diagram shows some of the options available for protecting oysters when growing them to market size (Figure 5).

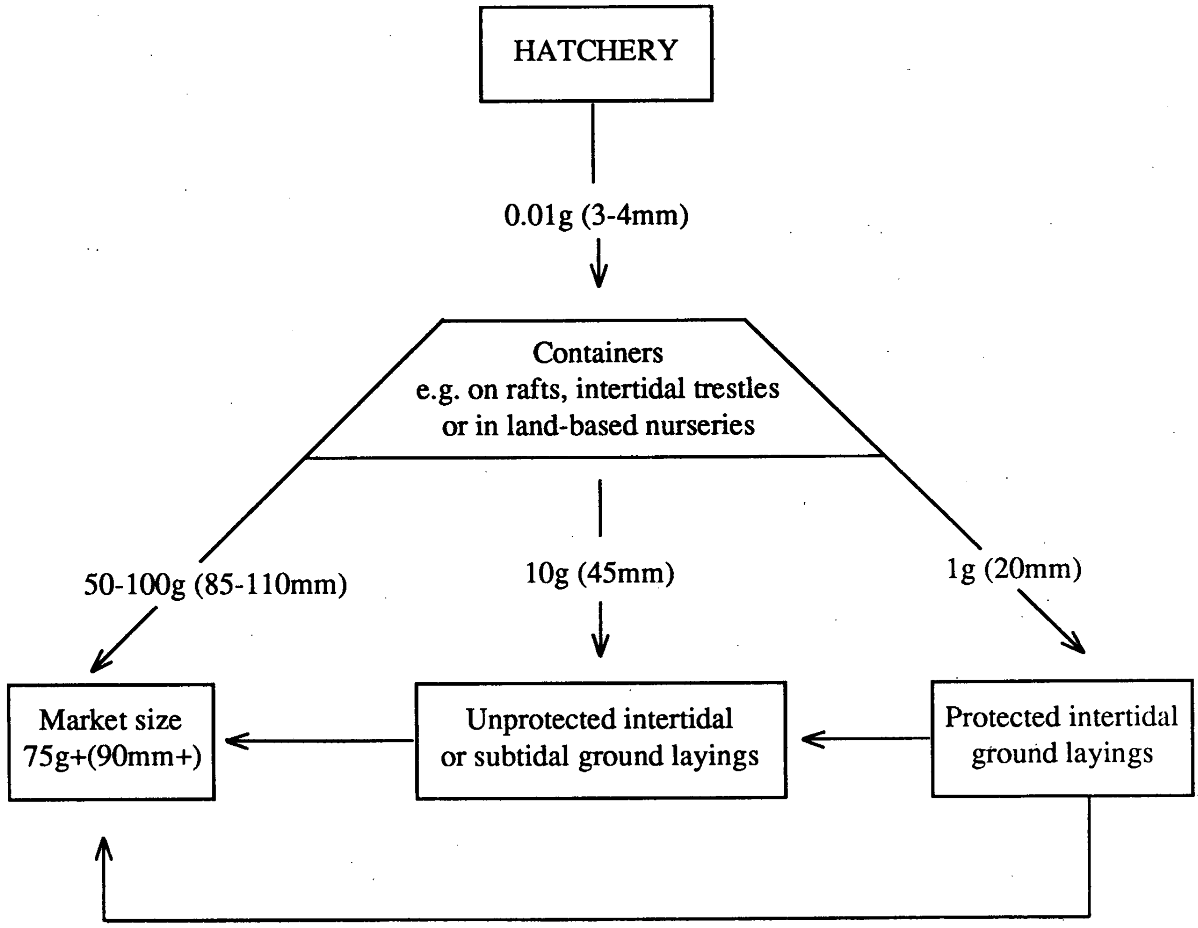


Figure 5 Flow diagram showing some options for growing hatchery seed to market size.

3.2.1 Intertidal culture

Oysters may be grown intertidally on the shore in containers on trestles. They may also be grown on the ground within protective, crab-proof, fenced plots or on unprotected plots if the oysters are large enough to resist crab attack. For optimum growth, the oysters should be submerged all of the time but, clearly, this is impracticable where access is required from the shore. Monthly visits are possible if the racks or ground lays are positioned at low water mark of spring tides, where they are submerged for about 90% of the time. This allows access for several hours during a spring tide. Oysters which are exposed for 3-4 h during low water periods of neap tides are too high up the beach for growth but should store well during the summer months.

Tray or bag culture is the most commonly used method for protecting oysters. Home-made trays using a wooden frame covered with plastic netting are probably the cheapest available to the cultivator who does not cost his labour. These may be single- or multi-compartmental as preferred. Light gauge timber (50 mm x 25 mm) is suitable for tray construction, since it is not too buoyant in its early days in the sea, nor too heavy for handling after becoming water-logged. A convenient size of tray for small spat (3-4 mm) has two compartments each 30 x 30 x 5 cm deep (Figure 6). The dimensions of the compartment should not be much larger than this size, since oysters do not remain evenly spread but wash into heaps along one side or corner of the tray. The plastic mesh is usually

Figure 6 Oyster trays of various sorts attached to a trestle at LWMST.

attached permanently to the bottom with wooden or plastic battens, while that on the top is temporarily battened for regular access during servicing. A 1.5 mm mesh is suitable for enclosing 10 mg (3-4 mm) seed but once these reach about 100 mg (8-10 mm) they can be transferred to 6 mm mesh. Using a mesh size appropriate to the size of the oyster is essential to ensure a good exchange of water through the tray. If wooden-framed trays are to be stacked more than two high, 5 cm spacers should be put between the trays to allow a good flow of water to the oysters.

Untreated timber is quickly eroded away in most coastal sites in the UK by the boring action of the gribble worm (Limnoria sp.), which is a small crustacean. The useful life of timber in the sea can be increased by several years by protecting it with a proprietary brand of chemical preservative. However, chemically preserved timber must be avoided or used with caution at sites with poor water exchange to minimise risks of chemical contamination. Preservatives containing TBT should not be used.

Commercially available trays take the form of 'lay-flat' plastic mesh flexible tubes or bags with openable ends, (Figure 7) or rigid open-topped plastic trays with moulded edges which enable them to be stacked (Figure 8). The bags (approximately 1 m x 0.5 m x 6 cm deep) may require an insert to provide rigidity but are also available with reinforced side meshes to prevent their collapse. The bags are available with various mesh sizes ranging from 4 mm to 18 mm. Stackable trays are also available in various sizes and meshes; dimensions up to 1 m x 0.5 m are a convenient size, for handling. Five trays with oysters and a sixth, empty, tray as a lid comprise a suitable number for a stack with an overall height of about 30 cm. Larger numbers of trays within a stack make it more unwieldy to handle and cause reduced growth in the upper levels. Rigid trays are probably more suitable for growing small spat in their first year on the beach, whereas bags are more popular and widely used for growing larger, older oysters.

Figure 7 Plastic bags on trestles. The bags are temporarily sealed at one end with a flexible plastic rod.

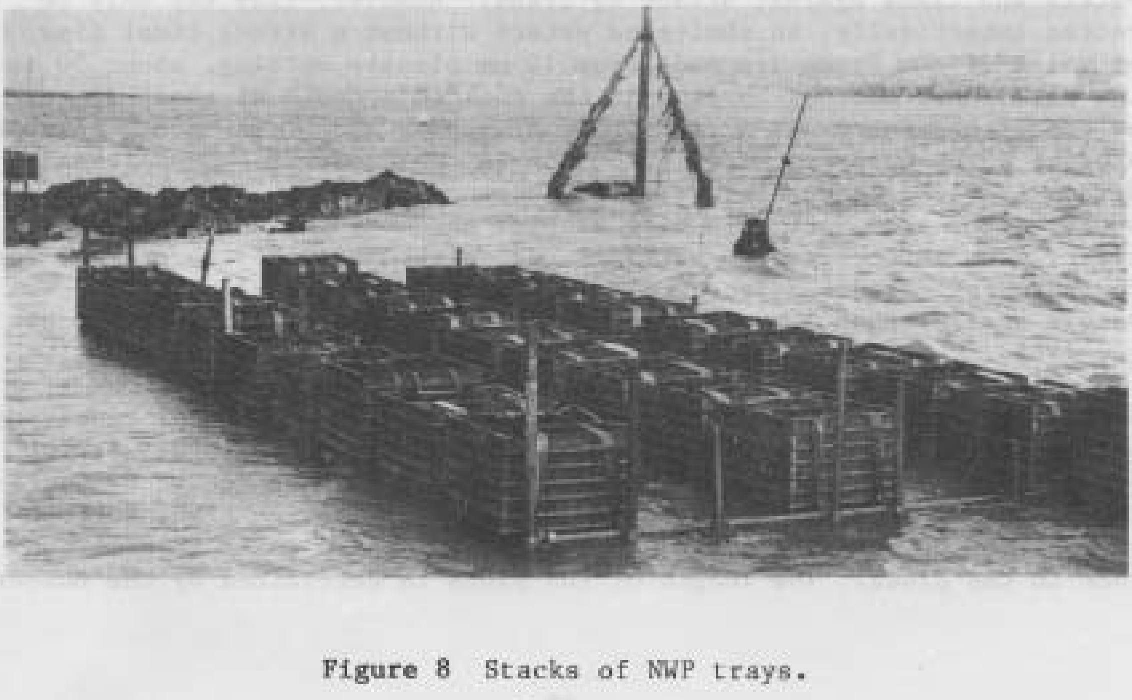


Figure 8 Stacks of NWP trays.

Metal racks are probably the most durable and versatile means of supporting trays on the foreshore. They should be positioned so that the trays are held 0.3-0.5 m above the sea bed. Two bars are suitable for supporting rigid trays but three may be necessary for flexible bags. Stabilising a rack to prevent it from toppling in excessive wind or wave action can be achieved by pushing its legs into the soil, or by weighting the legs with concrete, or by interconnecting adjacent parallel racks to provide a wide base. Rubber bands, cut from old motor car inner tubes, provide a quick and secure method of fixing trays to racks. These bands are looped round the rack, stretched over the tray and clipped by a plastic-covered metal hook to their opposite partner, using four bands per tray. When securing stacks of trays, several bands may be joined together to cover the extra distance involved. Stacks of open-topped trays are best secured by binding them together with one or two nylon straps. This also aids handling, especially when transporting trays up or down the beach. Because of their collapsible nature, bags should not be stacked more than one container deep. An ideal arrangement, adopted in some areas of France, is to secure each bag to the frame along one edge only and to slightly lap the other edge over that of its neighbour. At intervals of one to two months, the bags are flapped over 180° to redistribute the oysters, to dislodge silt, and to smother weed on the previously exposed upper surfaces.

Ground culture on subtidal or low intertidal lays is the traditional way of cultivating wild caught flat oysters in the British Isles. However, hatchery-reared seed require some form of protection during their early years in the sea to ensure good survival. Dare et al. (1983) found that Pacific oysters smaller than 10 g live weight (45 mm) are vulnerable to crab attack and require protection for 1-2 years until this size is reached. Although tray cultivation is the most widely practised and probably the most successful way of protecting oysters during this vulnerable period, other methods have been tried. Walne and Davies (1977) covered small ground plots of Pacific oysters, 0.5 to 5 g in size, with plastic netting with some success in the Menai Strait. However, net covers need frequent servicing in silt-laden waters, since they encourage rapid deposition of mud which may smother stock. The value of their commercial application remains to be demonstrated.

Protective fencing, used traditionally in France and the USA, can protect oysters and clams against attack by crabs. However, they can only be erected intertidally, in sheltered waters without a strong tidal flow. The walls of the fence are made from 10 mm plastic netting, about 50 cm high with their bottoms burried in the soil to a depth of about 15 cm. The top of the fence has a crab-proof overhang, made from smooth plastic material which faces outwards at 90° or 45° to the vertical position (Hanks, 1963; Marin et al., 1973; Smith et al., 1955). Experimental fences, up to 40 m x 20 m in size erected on muddy ground in the Menai Strait, were effective crab barriers and, although highly successful for growing mussel seed (Davies et al., 1980), were less so for Pacific oysters smaller than 10 g due to unacceptably high mortalities (Spencer et al., 1985).

Pacific oysters larger than 10 g are virtually crab-proof and, hence, can be transferred from trays, etc. to unprotected ground layings. Satisfactory large-scale intertidal pens can be made on soft ground by enclosing plots 2 m wide with plastic 12 mm mesh walls, 15 cm high, buried 7.5 cm into the soil and staked at intervals. These walls confine the stock to the plots. The length of the plots is determined by the number of stock. Walkways 0.5 m wide may be left between plots for access during planting, servicing, or harvesting. Similar plots can be prepared on hard ground, with suitable barriers to prevent washing out of stock. Once oysters have been relaid on the ground, they require little attention until market size is reached. The preparation of the ground depends largely on the site and requirements and resources of the cultivator. Ground can be cleared or improved for relaying in various ways - for example, soft muddy soil can be hardened by depositing shell or other suitable material onto the mud but the effort may be prohibitively costly for large areas. In our experience, soft muddy ground can be used for Pacific oyster culture without further treatment but it has been useful to harden narrow roadways for vehicular access to key points on the beach from whence a hand-pulled mud sledge provides a means for carrying equipment and stock.

3.2.2 Floating culture

Rafts may be convenient in some sheltered areas for cultivating oysters in suspended trays as an alternative to shore-based trays. Oysters on rafts are continually submerged and access to them is independent of tides. The water must be sufficiently deep to prevent the trays from grounding and must have a good tide run of 1-2 knots (50-100 cm per second) to ensure a good flow of water through the trays. Raft design can be relatively simple with two flotation compartments joined by timber spars from which the trays are suspended. Small rafts, capable of supporting a stack of trays, can be linked together as modular units but larger rafts, supporting many stacks, may be considered to be more appropriate. Raft trays are supported in frames which must be sufficiently strong to carry heavy loads and the stresses imposed by swift tides and wave action. Trials in the Menai Strait showed that stacks which swing with the prevailing current offer no growth advantage to oysters over those held rigidly in the water column. Frames may be shackled to a raft with galvanised chain and lifting gear may be required to haul them.

Comparative trials in the Menai Strait have shown no consistent differences in oyster growth in trays on a raft or on the shore (Spencer and Gough, 1978). Other sites may prove to be consistently more favourable for one or the other method of cultivation but, where sites are of equal value, the merits of the two systems may be judged on convenience and cost. Shore-based systems can be reached only at low water whilst rafts are usually accessible at all times. Rafts are costly structures to build and maintain and this must be considered in relation to the value of their crop which decreases, relative to the carrying capacity of the raft, as the spat grows. The selling price of oyster seed only approximately doubles for every ten-fold increase in weight up to about 10 g (Spencer *et al.*, 1985). Thus the value of a crop of 10 g oysters per unit area of raft is only one fifth of the value of 1 g oysters. It is unlikely, therefore, that raft culture could economically produce market-sized oysters, but it is satisfactory as a nursery for small oysters which are eventually moved to shore-based sites for further ongrowing.

Floating upwelling systems are specialised structures for growing nursery-sized oysters. Conventional trays are not ideal structures for holding oysters since they lie in the same plane as most tidal currents and, therefore, do not encourage an efficient exchange of water. One method of improving water flow through trays uses a deflector plate situated at the bottom of a floating, moored box (Figure 9). Water is driven by the tide into the throat of the box at its base, passing upwards through the stack of trays within the box before escaping through the top rear sections at

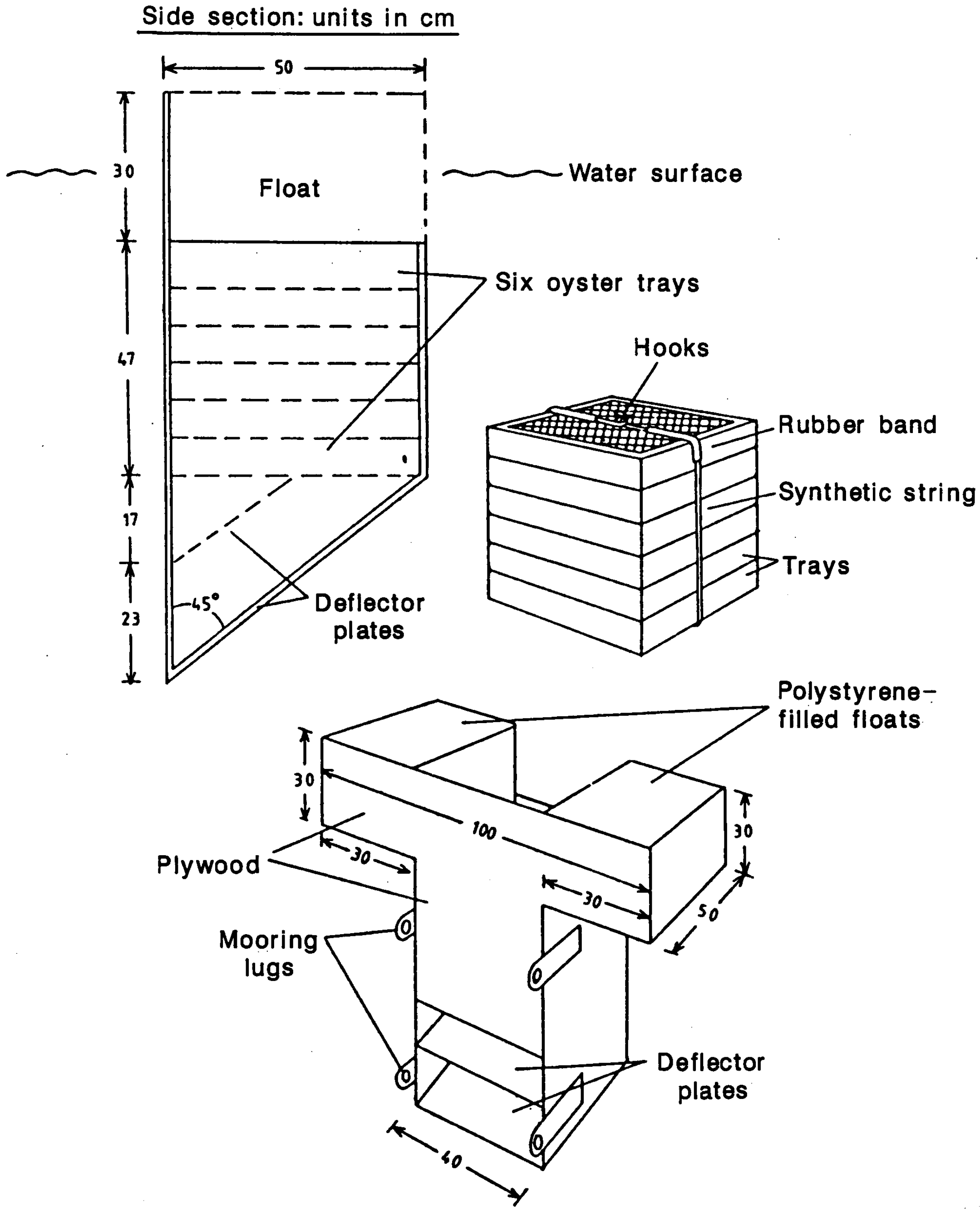


Figure 9 The design of an experimental plywood floating upwelling system (Spencer and Hepper, 1981).

the water surface. This floating upwelling system (flupsy) has shown good results in the Menai Strait where it was moored in a channel where current speeds reached 1-2 knots. The growth of Pacific oysters in a flupsy compared to that in trays on an intertidal rack nearby is shown in Figure 10.

The commercial application of the method was demonstrated in 1984 with a unit of eight flupsys built onto a 5 m x 5 m raft moored in an Essex creek (Peter French Oyster Farms). This was used to grow 200,000 flat oyster spat, 10 mm in size, to a mean weight of 5 g (35 mm), a convenient size

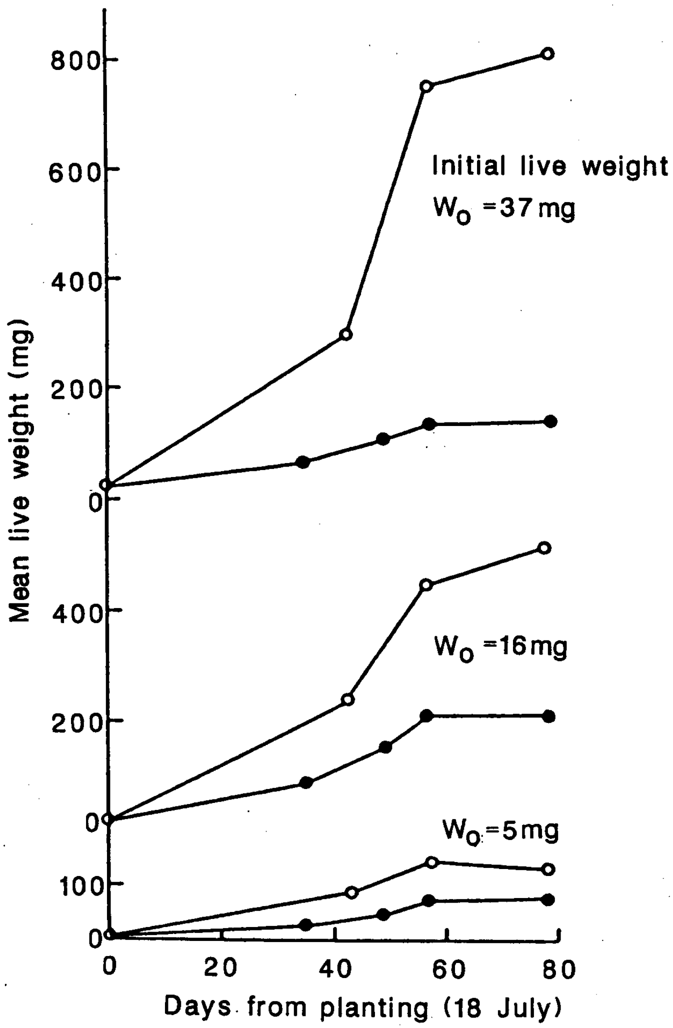


Figure 10 The growth of three batches of Pacific oysters in trays in a floating upwelling system (o) and on the foreshore (•) in the Menai Strait in 1978 (Spencer and Hepper, 1981).

for ongrowing in trays on trestles. Their initial bulk weight of 32 kg increased to 715 kg from June to October with 72% survival. At the end of the trial, the stock was in 160 trays (1 m x 0.5 m x 5 cm deep) at a density of 0.9 g per cm^2 of tray area. The weight of oysters which can be kept in these systems is dependent on the volume of water, and therefore of food, reaching the stock. Stocking density on the commercial raft reached 90 kg per flupsy but it is not known whether this was near to its maximum capacity. In contrast, the maximum capacity of the small experimental flupsy (Figure 9) was 10 kg, a biomass at which no further growth was possible at its locality in the Menai Strait.

Careful management of these systems is required. With experience, the operator should be able to determine maximum capacity of his flupsy at its site. Thereafter, he should avoid densities exceeding about 50% of the maximum capacity to ensure good growth and survival of the stock.

3.2.3 <u>Land-based and floating pumped upwelling systems</u>

These are now widely used in hatcheries and nurseries for growing small bivalves to 5-10 mm, a size at which they can readily withstand the

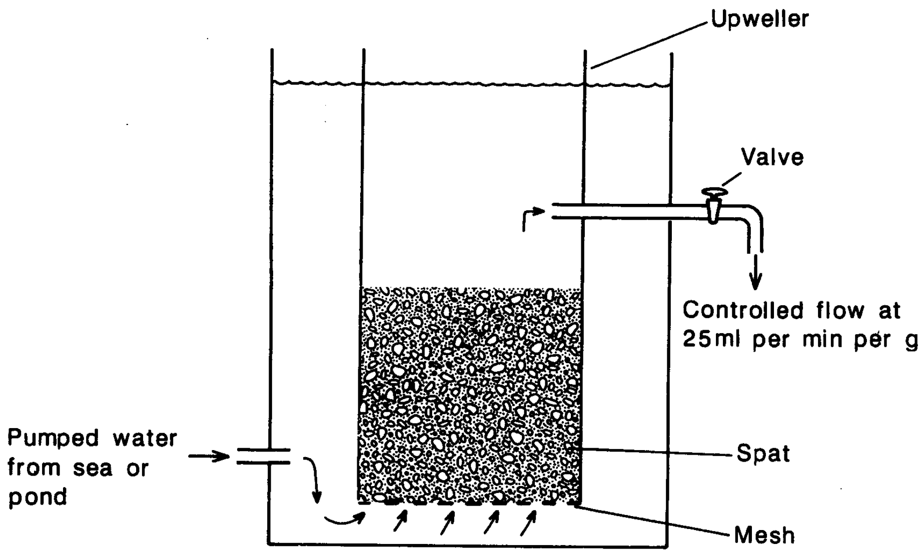


Figure 11 Diagrammatic view of a pumped upwelling system.

rigours of planting in the sea (Bayes, 1981). It is an intensive method of cultivation whereby the stock are kept in relatively small containers (Figure 11). Investment in trays and associated equipment is reduced but to a certain extent this is offset by the high cost of pumping. Impounded water in disused quarries, gravel pits, or purpose-built ponds may be used to supply a unit ashore or a raft. The raft may also be moored in a sheltered estuary at a site with an accessible electricity supply. One company has dispensed with pumped water in favour of an air lift, powered by compressed air supplied at low pressure (Williams, 1981).

Upwelling containers are usually PVC tubes sealed at the bottom with plastic mesh to retain the bivalves. The container's diameter and height depends on the capacity required. A container measuring 30 cm diameter by 60 cm high holds a maximum of about 5 kg of spat. When fitted with a 3.2 cm (1.25 inch) overflow and valve and with a 20 cm head of water, a water flow of 125 l per minute is possible at a specific flow rate of 25 ml per minute per gram live weight for 5 kg of spat. However, with narrower cylinders at high flows, water velocity may exceed 2-3 cm per second causing spat to lift from the bottom into the overflow pipe. It is then necessary to reduce the biomass of spat while retaining the specific flow rate.

Although a specific flow rate of 25 ml per minute per gram provides good growing conditions in the summer, the flow rate for best growth is dependent on the food content of the water. This interaction between flow rate and food content is an important aspect of the management of upwelling systems. Observations on experimental upwelling nurseries indicate that optimum uptake of food by juvenile oysters and clams occurs at flow rates adjusted to give 20% filtration of the particles flowing through an upweller (Spencer, 1988). When food is abundant, low flow rates (~ 20 ml per minute per gram) are required but when it is scarce high flow rates (~ 50 ml per minute per gram) are required to achieve 20% filtration. Automated control of flow rate to optimize growth of spat may be a possibility. This could be achieved using electronic sensors to continually measure the quantity of particles in the incoming and outgoing water. The information could be assessed by a central processor which controls the adjustment of an automatic valve to achieve 20% filtration.

A unit producing a million spat at 0.2 g mean weight (10 mm) would comprise one hundred upwellers (60 cm x 30 cm diameter) with a flow requirement of 12.5 m^3 of water per minute, at maximum stocking density to ensure good growing conditions in the summer. The time required to reach this size depends on initial spat size, and temperature and productivity of the water, and is likely to range from 4 to 8 weeks for small spat (0.01 g, 3-4 mm) in the warmest months.

3.3 Husbandry

The options available for growing seed oysters to market size (see flow diagram on page 17) range from permanent confinement of stock in trays throughout cultivation to temporary confinement until the stock reaches an intermediate size at which is can be transferred safely to ground layings. The cultivators preferred method should reflect the suitability of the area for ground cultivation and the extra cost of growing larger oysters in trays.

This sub-section emphasises the main cultivation requirements for growing Pacific oyster seed in trays to 10 g mean live weight and, thereafter, to market size on intertidal ground lays. Appendix 2 describes a procedure for handling spat on receipt from the nursery supplier.

3.3.1 Tray culture

Stocking density trials with Pacific oysters in the Menai Strait and elsewhere, using trays of various types and mesh sizes, have shown that high stocking levels cause poor growth, clumping (i.e. the fusion of two or more oysters), and high mortalities. The general conclusion is that,

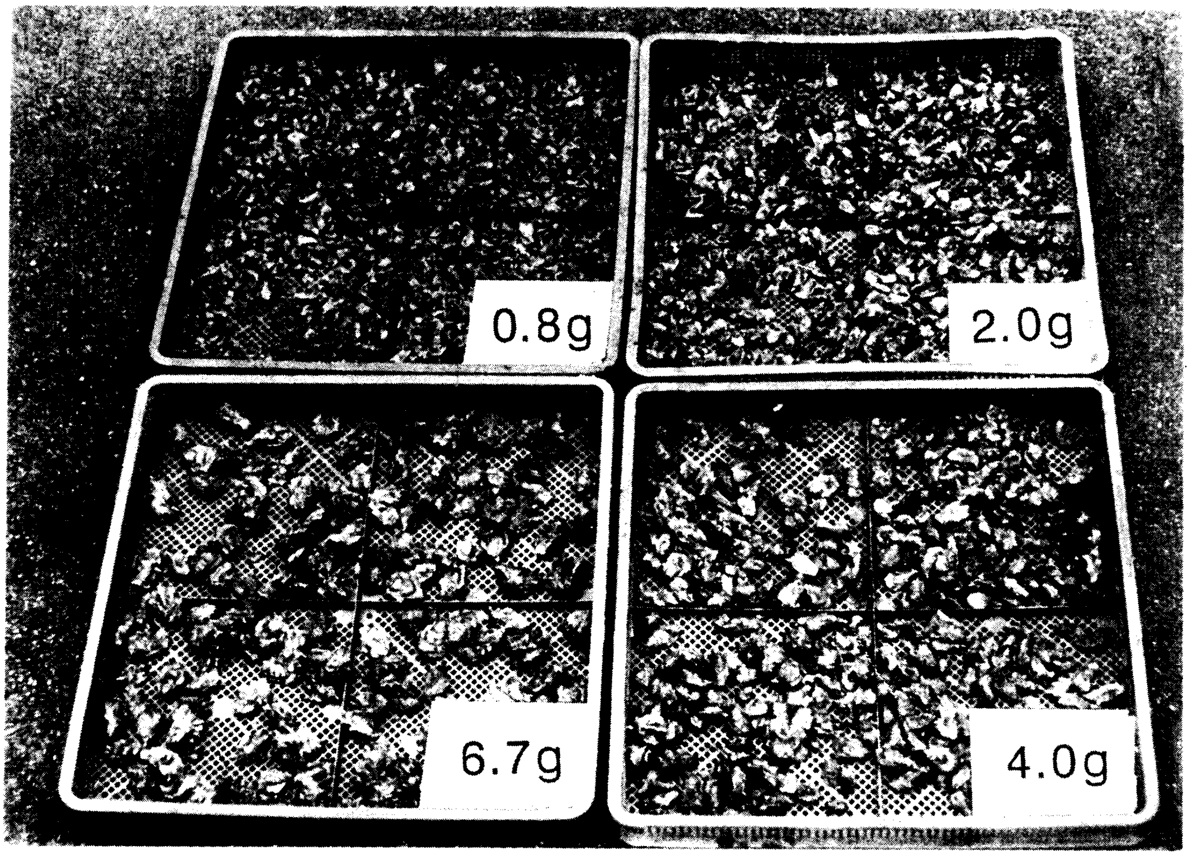


Figure 12 Four sizes of Pacific oysters stocked in NWP trays at 0.5 g per cm^2.

during the first two growing seasons, a density of about 1 g live weight of oysters per square centimetre of tray bottom (1 g per cm^2) is acceptable for short periods (one month) whilst densities above 2 g per cm^2 are acutely stressful to the oysters and should be avoided. It has become our practice to stock oysters at levels which do not exceed 0.5–1 g per cm^2 in trays with meshes of 5 mm or larger. Four sizes of Pacific oyster, stocked in North West Plastics (NWP) trays at 0.5 g per cm^2, are shown in Figure 12. Oysters too small for 5 mm mesh are stocked at a lower level (2.5 oysters per cm^2; 0.02–0.2 g per cm^2) to ensure a good start to their new life in the sea.

In winter, when growth is very slight, oysters can be stocked at densities of up to 2 g per cm^2 because their food and water requirements are very much reduced. However, silt deposition is usually greater in winter and regular servicing may be required to prevent smothering.

With tray culture, oyster growth in relation to size and temperature requires careful consideration. Oyster size and seawater temperature have

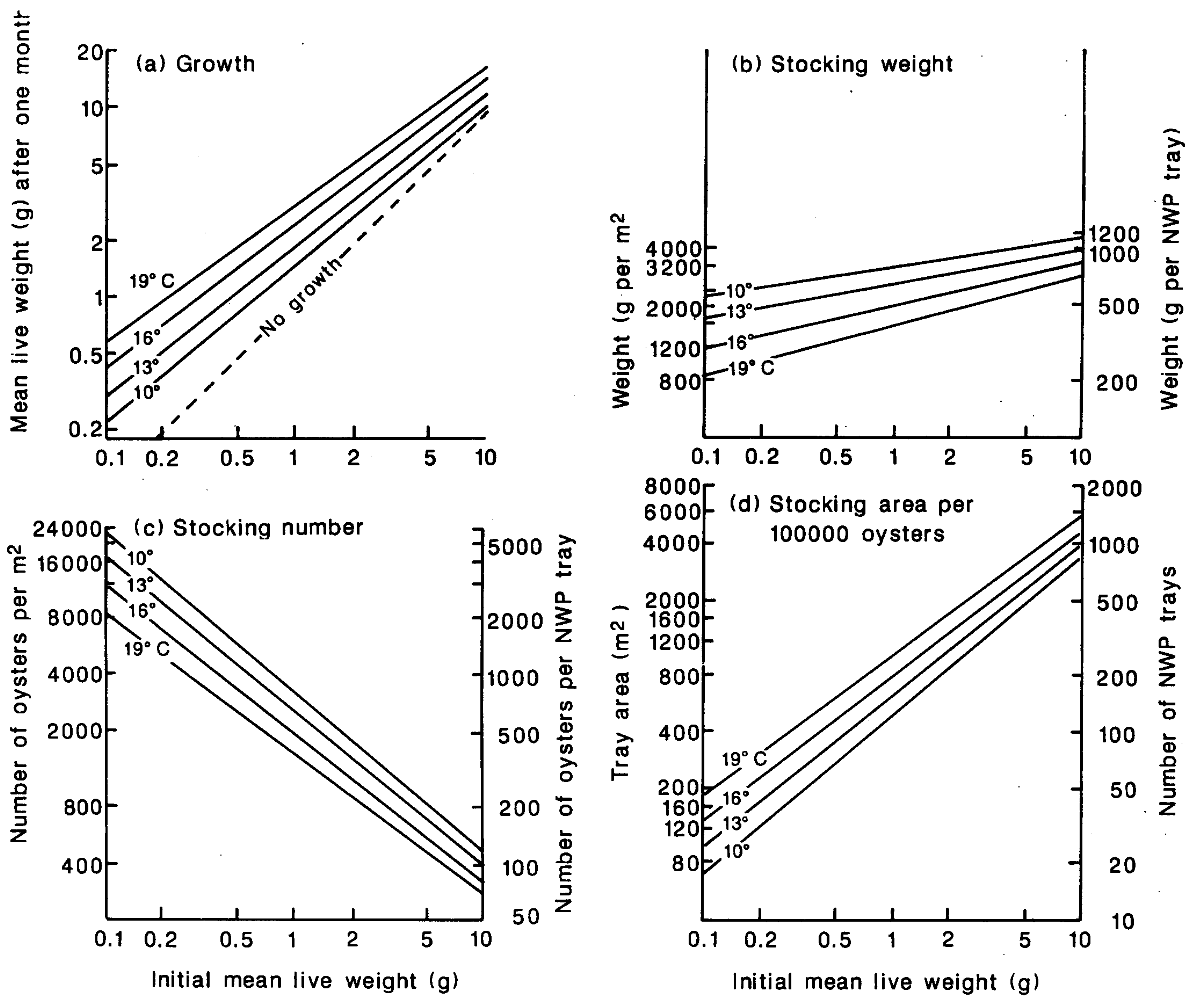


Figure 13 Pacific oysters: calculated growth and tray stocking densities required to achieve a target density of 0.5 g live weight of oysters per cm^2 of tray area after one month in the sea. Data are derived from field trials in England and Wales (Spencer _et al._, 1978 and 1985).

a large and fairly predictable effect on growth. A knowledge of the relationship between these factors presents the cultivator with the opportunity to manage tray stocking levels to achieve good growth and survival. Growth data shown in Figure 13(a), derived from observations at various sites in England and Wales, have been used to calculate the tray stocking requirements for Pacific oysters to achieve a target density of 0.5 g per cm^2 after one month. These data are expressed in various ways as an aid to tray management and are shown in Figure 13(b–d). Options, such as raising the target density to 1 g per cm^2, allow stocking biomass to be increased approximately by the same proportion. Similarly, increasing the interval between servicing requires the lowering of the stock weight to a level commensurate with the length of the interval and of the sea temperatures during that interval.

To use information in Figure 13 for the management of tray density, a knowledge of seawater temperature at the site is required. The mean monthly values for various coastal sites (see Table 2) provide some idea of seasonal and geographical variation around the country and may be used in the absence of specific information for the site.

Table 4 shows examples of initial stocking densities required for 0.3 g Pacific oysters held in NWP trays to yield 0.5 g per cm^2 after one month at three temperatures.

Table 4 Examples of initial stocking densities of Pacific oysters in trays

Expected mean monthly temperature (°C)	Initial live weight (g)	Predicted live weight (g)	Initial density per NWP tray	
			(a) weight (g)	(b) number
10	0.3	0.55	680	2220
16	0.3	1.0	375	1250
19	0.3	1.3	290	960

Table 5 Growth, as percentages of the population of Pacific oysters, retained by sieves of different mesh sizes, in trays in the Menai Strait in 1978. The mean live weights (g) are shown in parentheses

Month	Mean sea temperature (°C)	Sieve size (mm)				
		2	7	11	18	25
April	7.5	100 (0.01)				
May	11.4	100 (0.02)				
June	13.4	83 (0.06)	17 (0.12)			
July	15.3	16 (0.10)	65 (0.21)	19 (0.40)		
August	15.8	1 (0.19)	78 (1.5)	21 (3.0)		
September	15.5		7 (0.6)	48 (1.8)	25 (3.7)	20 (6.6)

Frequency of servicing and adjustment of stocking density are important factors which contribute to the welfare of oysters in trays. In the first year, with small mesh trays, frequent servicing and adjustment of stocking density are usually required. Although it is cost efficient in the use of trays to regrade monthly, it is labour intensive. Longer intervals between regrading may be possible depending on the rate of siltation and fouling within the tray. From the second year onwards, frequent and excessively rough handling retards growth. It is then usually beneficial to limit regrading to three- to six-monthly intervals but with regular checks to ensure control of silting and fouling.

No matter how uniform the initial size of the oysters are, individuals grow at different rates to produce a wide range of sizes after a few months. A typical distribution of sizes within a population is given in Table 5, by the percentage and mean weight of oysters retained by sieves of different mesh sizes in successive months. Several hundred thousand spat of less than 1 g can be graded quickly by one person using a hand sieve (0.25-0.5 m^2 surface area) shaken gently in a trough of water, but larger numbers and larger oysters require mechanical grading. A range of hand sieves of 2 to 25 mm mesh is required for dealing with spat up to 5 g.

3.3.2 Intertidal ground layings

Experiments to determine the most suitable stocking density for Pacific oysters relaid intertidally on the ground have been made for 1 g oysters within a protective fence and for around 10 g oysters in unprotected pens. One metre square plots were established on soft, muddy ground at 10% tidal exposure in the Menai Strait and growth and survival were recorded over a period of time in the following way:

(i) The growth of small oysters within a protective fence was tested by relaying 1.3 g oysters at densities ranging from 160 to 2,000 per m^2 (Table 6(a)). After three months, no differences were observed in the mean weights of the oysters at densities of up to 640 per m^2; 50% or more of the individuals were larger than 10 g and, therefore, of crab-proof size. Oysters relaid at 1040 and 2000 per m^2 were smaller than those at lower densities. After a further season's growth, the relationship between stocking density and growth and survival was even more distinct. Those initially at 160 and 240 per m^2 were of similar weight, but at higher densities the mean weight and proportion of marketable oysters decreased with increasing density. The practical significance of this is that stocking densities of 500-600 per m^2 can be employed in growing stock to about 10 g but a lower level, of about 200 per m^2, is required in growing them to market size. Thinning, however, requires considerable effort and it may be more cost effective to stock initially at 200 per m^2 and leave them undisturbed until they reach market size.

(ii) The growth of large oysters was tested by relaying 8.6 g Pacific oysters (44 mm shell length) in unprotected pens at densities ranging from 50 to 200 oysters per m^2. The trial was started in April 1977 and growth and survival were recorded at the end of two consecutive growing seasons (Table 6b). More than 60% of the population at each density reached minimum market size (50 g) in 8 months and maximum market size (100 g) in 16 months. Stocking density within the range of 50-200 per m^2 did not seriously affect growth and survival, which confirmed the conclusion drawn from Table 6(a) that oysters can be grown to market size at about 200 per m^2.

Table 6(a) The effect of stocking density on the growth and survival of 1.3 g Pacific oysters, relaid intertidally on the ground inside a protective fence on 1 August 1977

Initial number (per m^2)	10 November 1977				18 October 1978			
	Mean weight (g)	Total weight (kg/m^2)	Percentage > 10 g	Survival (%)	Mean weight (g)	Total weight (kg/m^2)	Percentage > 50 g	Percentage survival
160	11.8	1.6	54	86	57.6	6.7	72	72
240	11.9	2.5	58	87	58.9	8.6	66	61
400	11.4	3.8	68	84	53.1	13.5	48	64
640	10.9	6.0	54	86	47.6	17.3	41	57
1,040	7.0	5.4	21	74	40.6	15.7	10	37
2,000	6.5	9.6	10	74	34.4	19.8	17	29

Table 6(b) The effect of stocking density on the growth and survival of 8.6 g Pacific oysters relaid intertidally on unprotected ground layings on 6 April 1977.

Initial number (kg/m^2)	13 December 1977				5 October 1978			
	Mean weight (g)	Total weight (kg/m^2)	Percentage > 50 g	Percentage survival	Mean weight (g)	Total weight (kg/m^2)	Percentage > 100 g	Percentage survival
50	58.6	2.5	66	80	129.2	5.0	66	78
100	61.4	4.4	NR	72	128.4	8.8	83	68
150	61.2	6.9	NR	71	128.0	13.3	78	69
200	61.6	8.2	78	67	127.8	16.2	79	64

NR = not recorded

(iii) Annual growth of Pacific oysters of various sizes, relaid at the recommended density of 200 per m^2 on ground layings in the Menai Strait, is shown in Figure 14. The survival of these oysters after two years (Figure 15) is very sensitive to their size at relaying. These data show that 10 g oysters would be expected to grow to about 70 g in two years with an average survival of 50%.

3.3.3 Costs of cultivation

1990 hatchery prices of Pacific oysters range from £7.50 to £30 per 1000 for stock of 3 to 30 mm in size. The value of market-sized oysters is variable depending on the outlet but may reach £200 or more per 1000 oysters at first sale.

The cost of growing 3-4 mm Pacific oysters to market size was assessed in costed trials in the Menai Strait. Two strategies were adopted in two four-year trials. In the first trial, 166,000 seed were grown in trays for 1-1.5 years and then on intertidal ground lays to market size. In the second trial, 62,000 seed were grown to market size solely in trays.

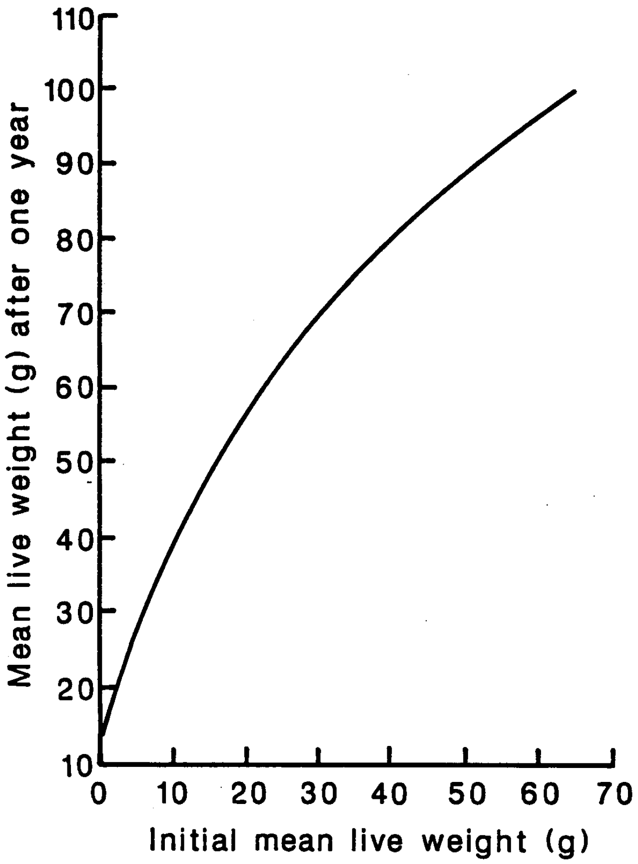


Figure 14 Annual growth of Pacific oysters, stocked initially at 200 oysters per m^2, on intertidal ground layings in the Menai Strait in 1979 to 1981 (redrawn from Spencer et al., 1985).

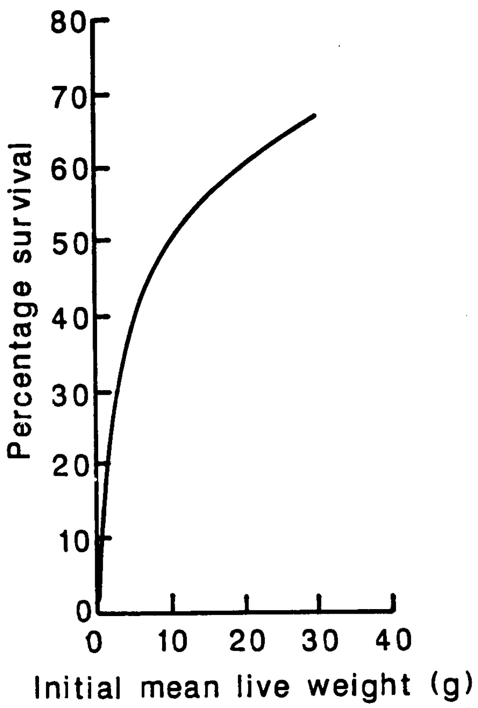


Figure 15 Percentage survival of Pacific oysters on intertidal ground layings in the Menai Strait for the two-year period November 1979 to November 1981, related to size (g) at the beginning of the period (redrawn from Spencer et al., 1985).

Table 7 Some statistics of growing Pacific oysters to market size in costed trials by (a) tray and ground culture and (b) tray culture alone

	(a)	(b)
% survival	22	48
Final mean live weight (g)	85	80
Costs as percentage of final value	56	52
Number of spat needed per 1000 marketed oysters	4700	2100
Net income (£ per 100,000 seed; 1982 prices)	1630	3460

Little difference was found in the final mean sizes of the oysters grown by the different strategies (85 g and 80 g mean live weight) but survival was twice as high for oysters grown solely in trays. Since the costs of rearing the oysters as a proportion of their final values were similar between strategies, profitability was related to survival. Thus, even though tray culture is relatively expensive, improved survival should provide a better yield in net income, in this instance, of about twice that of ground culture (Table 7).

4. LEGAL ASPECTS OF CULTIVATION

4.1 Registration of shellfish farms

A shellfish farmer must register his business with, the Ministry of Agriculture, Fisheries and Food, the Welsh Office Agriculture Department (Appendix 1), or the Department of Agriculture and Fisheries for Scotland under the Fish Farming and Shellfish Farming Business Order 1985*. The purpose of registration is to assist MAFF in dealing with outbreaks of disease if these should occur. Registered businesses are required to keep a record of the stock movements on and off site and to submit to the appropriate Fisheries Department a simple summary of movements each year.

4.2 Control of deposits

A cultivator cannot legally deposit oysters, clams or other molluscan shellfish in coastal waters of England or Wales except under licence. This legislation is intended to control the spread of some pests and diseases which are present in some areas and which are listed below:

*Note: Copies of Acts, Orders and other Government legislation are available from: Her Majesty's Stationery Office, Publications Centre, P.O. Box 276, London SW8 SDT.

- Bonamia ostreae, a parasite which infects the blood cells of native oysters causing high mortalities of infected oysters. It is harmless to man.

- The American whelk tingle (Urosalpinx cinerea).

- The slipper limpet (Crepidula fornicata).

- The "red worm" (Mytilicola intestinalis) which is a crustacean parasite in the gut of mussels, but may also occur in oysters and some species of clam. It is harmless to man.

The distribution of these pests and diseases in England and Wales is shown in Appendix 1 (Figure A1). An explanatory leaflet issued by MAFF, describing the licensing system, is reproduced in Appendix 3 and a specimen copy of a special licence is at Appendix 4. Cultivators who wish to make deposits of oysters, clams, or other molluscan shellfish, irrespective of whether they originate from a hatchery, from natural stocks, or are imported, should apply to one of the addresses shown in Appendix 3 for a licence.

4.3 Rights of shellfish cultivators in the sea

At present, the shellfish cultivator has limited legal protection of his stock. Molluscs, grown in trays in public waters are protected by the Theft Act 1968 and the Criminal Damage Act 1971, while shellfish beds covered by private rights of fishery or by Several Order are protected against theft or damage by the provision of section 7 of the Sea Fisheries (Shellfish) Act 1967, provided that the beds are adequately marked.

4.3.1 Public rights

The public has a common law right to fish tidal waters, in rivers and estuaries and in the sea within territorial waters (12 nautical miles from baselines), except where a private property right has been obtained which excludes the common right. Subject to certain constraints, anyone can grow molluscs in which a public right of fishery exists. The constraints are as follows:

- The public right of fishery must not be interfered with.

- If a Regulating Order (see below) for oysters or other specified shellfish exists, then they may be taken only in accordance with the terms of the order and any regulations made under it.

- If the cultivator wishes to erect frames, trays, or other structures on the sea bed or foreshore, he must have the consent of the Crown Estate Commissioners, and of the Department of Trade if the structures are hazardous to navigation, and also comply with any planning permission from the local authority.

- In areas designated as sites of Special Scientific Interest (SSSI's), the cultivator will need the permission of the Nature Conservancy Council (NCC) to undertake certain operations. Permission will usually be given unless the operation conflicts with the specific purposes for which the site was designated by the NCC.

4.3.2 Several Orders

A cultivator who wants to have additional protection for stock kept in public waters may apply for a right of several fishery. Orders establishing these are granted in England and Wales by the Minister of Agriculture, Fisheries and Food and the Secretary of State for Wales, under the Sea Fisheries (Shellfish) Act 1967. They are granted, for a fixed period, to an individual, a cooperative, or a responsible body, to enable the grantee to cultivate the sea bed within a designated area of water and to conserve and develop stocks of shellfish thereon. Several rights may also be granted to a Sea Fisheries Committee who cannot cultivate stocks in its own right but may lease rights of several fishery subject to the consent of the Fisheries Departments. The applicant must satisfy the Minister that the fishery will benefit from cultivation. This aspect is monitored by periodic surveys by MAFF, to ensure that the ground under Several Order is properly cultivated and that the order is being properly put into effect, or the right may be terminated.

4.3.3 Regulating Orders

A Regulating Order may be granted by the Minister of Agriculture, Fisheries, and Food to a responsible body such as a Local Authority, Harbour Board, or Sea Fisheries Committee, to enable it to regulate a natural fishery. The fishery may then be fished by the public in accordance with the terms of the order, subject to the observance of any byelaws or regulations made by the controlling body, and on payment of any tolls or royalities which may be charged by it.

4.3.4 Private ownership

Private property rights preclude public fishing in some tidal waters. These rights may have been acquired in one of the following ways:

- By grants of rights of a fishery to individuals by the Crown before the Magna Carta (1215).
- By a private Act of Parliament (up to 1868) conferring several fishery rights on boroughs such as Rochester and Colchester.
- By grants of Royal Charter to boroughs.
- By grant of several fishery rights under the Sea Fisheries Act 1868, and latterly under the Sea Fisheries (Shellfish) Act, 1967.

4.4 Public health

Some shellfish growing waters around our coast are contaminated by domestic and industrial discharges and shellfish grown in them may not meet the standards for safeguarding public health. Shellfish consumers in England and Wales are protected by statutory powers, administered by Local Government, under the Public Health (Shellfish) Regulations 1934 and 1948, and the Food Act 1984. Under these regulations, shellfish grown in polluted waters subject to a closure order cannot be sold for consumption unless they are cooked, or cleansed free of bacteria in an approved purification plant, or relaid for several months in clean natural waters (West and Wood, 1985; West, 1986). Cultivators embarking on shellfish growing should consult their Local Authority for advice on the water quality and information on restrictions which may apply to the area concerned.

Shellfish sanitation is also of prime concern to overseas trade. Some European countries will not accept bivalves for direct consumption from overseas unless certified as having been purified in an approved depuration plant prior to export.

The European Community is moving towards common standards of shellfish hygiene. From 1993, all shellfish within or moved into and out of the UK for consumption will have to meet uniform public health standards.

5. DISCUSSION

Landings of cultivated Pacific oysters from hatchery-reared stocks do not contribute significantly to the official statistics because most are sold, unrecorded, through local outlets. However, it is estimated that UK production of Pacific oysters in 1986 was about 300 t spread over more than 300 sites. Trial plantings by MAFF, and the existence of many widely dispersed cultivators, demonstrate that good oyster growth is still supported by many of our sheltered waters. If all of the estimated 100 million Pacific oysters and clams currently produced by British hatcheries were planted in our waters with 25% survival to market size, only 25 hectares of ground, at 75 t per hectare, would be occupied. But there are about 16,000 hectares of public ground leased to individuals or companies and much more not under any form of lease. Hence, the potential for shellfish growing is enormous but, as yet, scarcely exploited by the cultivator.

The Pacific oyster is readily available from commercial hatcheries. It is hardy and fast growing in a wide range of habitats. Costed trials have shown that it produces a reasonable financial return for effort. At present, most producers sell their cultivated oysters directly to outlets such as shellfish bars, restaurants, hotels and public houses. As yet, this market is unsaturated and could take up a substantial increase in production. Present trends indicate an increasing growth in production and, hopefully, market demand will develop more rapidly, with increased and consistent production selling through wholesale outlets with an organised advertisement of the product. Less than 100 years ago, the oyster was a very popular food, eaten in large numbers by a wide cross-section of the community. The British public has lost that taste for oysters, which are now eaten by the gourmet, or as a novelty, but there is no reason why that taste should not be recultivated.

Reference to published work, where relevant, is given in the text. Additional references (Appendix 5) are given to enable the reader to gain more breadth of understanding of shellfish cultivation.

6. REFERENCES

Ayres, P. A., 1978. Shellfish purification in installations, using ultraviolet light. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft. (New Series), (43): 20 pp.

Bayes, J. C., 1981. Forced upwelling systems for oysters and clams using impounded water systems. pp. 73-83. In: Claus, C., de Pauw, N. and Jaspers, E. (Editors), Nursery Culturing of Bivalve Molluscs. Spec. Publ. Eur. Maricult. Soc., Bredene, Belgium, (7): 394 pp.

Cole, H. A., 1956. Oyster Cultivation in Britain. Her Majesty's Stationery Office, London, 43 pp.

Dare, P., Davies, G., and Edwards, D. B., 1983. Predation on juvenile Pacific oysters (Crassostrea gigas Thunberg) and mussels (Mytilus edulis L.) by shore crabs (Carcinus maenas (L.)). Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, (73): 15 pp.

Davies, G., Dare, P. J. and Edwards, D. B., 1980. Fenced enclosures for the protection of seed mussels (Mytilus edulis L.) from predation by shore crabs (Carcinus maenas (L.). Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, (56): 14 pp.

Hancock, D. A., 1954. The destruction of oyster spat by Urosalpinx cinerea (Say) on Essex oyster beds. J. Cons. int. Explor. Mer., 20: 186-196.

Hancock, D. A., 1955. The feeding behaviour of starfish on Essex oyster beds. J. mar. biol. Ass. UK., 34: 313-331.

Hancock, D. A., 1969. Oyster pests and their control. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft (New Series), (19): 30 pp.

Hanks, R. W., 1963. The soft-shell clam. Circ. Fish. Widl. Serv., Wash., (162): 16 pp.

Key, D., and Davidson, P. E., 1981. A review of the development of the Solent oyster fishery 1972-1980. Lab. Leafl., MAFF Direct. Fish. Res. Lowestoft, (52): 36 pp.

MAFF, 1905-1986. Sea Fisheries (England and Wales) Statistical Tables 1903 to 1985. HMSO, London.

Marin, J., Bellail, R. and Latrouite, D., 1973. Prédation de l'huitre plate, Ostrea edulis, par le crab enragé, Carcinus maenas. ICES CM 1973/K:11 5 pp (mimeo).

Milne, P. H., 1972. Hydrography of Scottish west coast sea lochs. DAFS Mar. Res., (3): 50 pp.

Minchin, D. and Duggan, C. B., 1989. Biological control of the mussel in shellfish culture. Aquaculture, 81: 97-100.

Philpots, J. R., 1890. Oysters and All About Them. Vols I and II. John Richardson and Co., London, 1370 pp.

Pichot, Y., Comps, M., Tige, G., Grizel, H. and Rabouin, M.-A., 1979. Recherches sur Bonamia ostreae gen. n. sp. n., parasite nouveau de l'huître plate Ostrea edulis L. Rev. Trav. Inst. Pech. Marit., 43: 131-140.

Smith, O. R., Baptist, J. P. and Chin, E., 1955. Experimental farming of the soft-shell clam, Mya arenaria, in Massachusetts, 1949-1953. Comml. Fish. Rev. 17 (6): 1-16.

Spencer, B. E., 1988. Growth and filtration of juvenile oysters in experimental outdoor pumped upwelling systems. Aquaculture, 75: 139-158.

Spencer, B. E., and Gough, C. J., 1978. The growth and survival of experimental batches of hatchery-reared spat of *Ostrea edulis* L. and *Crassostrea gigas* Thunberg, using different methods of tray cultivation. Aquaculture, 13: 293-312.

Spencer, B. E., Gough, C. J., and Thomas, M. J., 1985. A strategy for growing hatchery-reared Pacific oysters (*Crassostrea gigas* Thunberg) to market size - experiments and observations on costed small-scale trials. Aquaculture, 50: 175-192.

Spencer, B. E., and Hepper, B. T., 1981. Tide-powered upwelling systems for growing nursery-size bivalves in the sea. pp. 283-309. In: Claus, C., de Pauw, N. and Jaspers, E. (Editors). Nursery Culturing of Bivalve Molluscs. Spec. Publ. Eur. Maricult. Soc., Bredene, Belgium, (7): 394 pp.

Spencer, B. E., Key, D., Millican, P. F., and Thomas, M. J., 1978. The effect of intertidal exposure on the growth and survival of hatchery-reared Pacific oysters (*Crassostrea gigas* Thunberg) kept in trays during their first ongrowing season. Aquaculture, 13: 191-203.

Walne, P. R., 1956. The biology and distribution of the slipper limpet (*Crepidula fornicata*) in Essex rivers. Fishery Invest., Lond., Ser. 2, 20 (6): 50 pp.

Walne, P. R., 1958. Growth of oysters (*Ostrea edulis* L.). J. mar. biol. Assoc. U.K., 37: 591-602.

Walne, P. R., and Davies, G., 1977. The effect of mesh covers on the survival and growth of *Crassostrea gigas* Thunberg grown on the sea bed. Aquaculture, 11: 313-321.

West, P. A., 1986. Hazard analysis critical control point (HACCP) concept: application to bivalve shellfish purification systems. J. R. Soc. Hlth., 106 (4): 133-140.

West, P. A., and Wood, P. C., 1985. Control of food poisoning risks associated with shellfish. J. R. Soc. Hlth, 105 (1): 15-21.

Williams, P., 1981. Offshore nursery culture using the upwelling principle. pp. 311-315. In: Claus, C., de Pauw, N. and Jaspers, E. (Editors). Nursery Culturing of Bivalve Molluscs. Spec. Publ. Eur. Maricult. Soc., Bredene, Belgium, (7): 394 pp.

APPENDIX 1: Names and addresses of suppliers of oyster seed and equipment and organisations associated with cultivation.

1. Hatchery and nursery seed

Seasalter Shellfish (Whitstable) Ltd., The Harbour, Whitstable, Kent CT5 1AB (tel. 0227 272003).

Guernsey Sea Farms, Parc Lane, Vale, Guernsey, Channel Islands (tel. 0481 47480).

2. Oyster containers and plastic netting

Bridport Gundry Netting Ltd., The Court, Bridport, Dorset DT6 3QU (tel. 0308 56666).

Fothergill Engineered Fabrics Ltd. PO Box 1, Littleborough, Lancs OL15 9QP (tel. 0706 78831).

Mesh Tech International Ltd, Beech House Business Centre, Hillyfields, Upton Cross, Liskeard, Cornwall PL14 5BE (tel. 0579 62745).

Netlon Ltd., Kelly St., Blackburn BB2 4PJ (tel. 0254 62431).

Nortene Ltd., Linenhall House, Stanley St., Chester CH1 2LR (tel. 0244 46193).

Northwest Plastics Ltd., Mosley Common Road, Worsley, Manchester M28 4AJ (tel. 061 790 4433).

3. Government departments and other organisations

(a) Administration (licensing, registration, Several Orders etc.)

Ministry of Agriculture, Fisheries and Food, Fisheries Division 2A, Nobel House, 17 Smith Square, London, SW1P 3JR (tel. 071 238 5947).

Welsh Office Agriculture Department, Division 2B, New Crown Buildings, Cathays Park, Cardiff CF1 3NQ (tel. 0222 823567).

Sea Fisheries Inspectorate, Ministry of Agriculture, Fisheries and Food, Nobel House, 17 Smith Square, London, SW1P 3JR (tel. 071 238 5808).

Department of Agriculture and Fisheries for Scotland, Pentland House, 47 Robb's Loan, Edinburgh, EH14 1TW (tel. 0315 568400).

Nature Conservancy Council, Northminster House, Peterborough, PE1 1UA (tel. 0733 40345).

Crown Estate Commissioners, Crown Estate Office, 16 Carlton House Terrace, London SW1Y 5AH (tel. 071 210 4311).

Note: The reference to proprietary products in this leaflet should not be construed as an official endorsement of these products, nor is any criticism implied of similar products which have not been mentioned.

(b) Scientific advice

Ministry of Agriculture Fisheries and Food, Fisheries Laboratory, Benarth Road, Conwy, Gwynedd LL32 8UB (tel. 0492 593883).

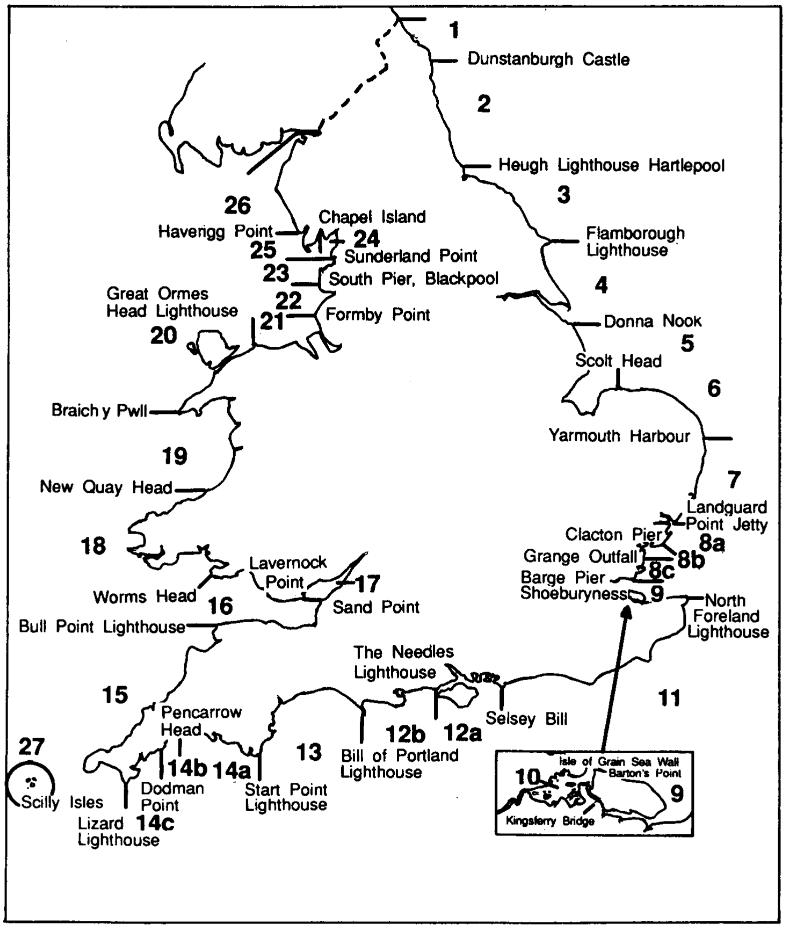
Ministry of Agriculture, Fisheries and Food, Fish Diseases Laboratory, The Nothe, Weymouth, Dorset DT4 8UB (tel. 0305 772137).

(c) Commercial advice

Shellfish Association of Great Britain, Fishmongers' Hall, London Bridge, London EC4R 9EL (tel. 071 626 3531).

(d) Central contact for local Sea Fisheries Committees

The Association of Sea Fisheries Committees of England and Wales, 11 Clive Avenue, Lytham St. Annes, Lancs FY8 2RU (tel. 0253 721848).



Key: Areas 1, 3, 5, 6, 19, 20, 21, 22, 23, 26 and 27 = no pests or diseases recorded; Areas 24 and 25 = *Mytilicola* only; Area 4 = *Crepidula* only; Areas 2, 7, 10, 11, 13, 14(a) (b), 15 16, 17, and 18 = *Mytilicola* and *Crepidula;* Area 9 = *Mytilicola, Crepidula* and American tingle; Areas 12(a) (b) and 14(c) = *Bonamia, Mytilicola* and *Crepidula;* Areas 8(a) (b) (c) = *Bonamia, Mytilicola; Crepidula* and American tingle.

Figure A1. Areas designated and numbered in the Molluscan Shellfish Control of Deposit) Order 1974, as varied by the Molluscan Shellfish (Control of Deposit) (Variation) Order 1983.

APPENDIX 2: Recommended procedure for handling and transporting nursery spat into trays.

The following example shows the necessary steps for accommodating 50,000 Pacific oyster spat (mean shell length 9 mm, and mean live weight 0.15 g) in NWP trays in the Menai Strait in May.

1. Transportation

The nursery will transport the seed quickly to its destination (usually within 24 h by post). The seed are normally packed (damp) in a sealed plastic bag, within an expanded polystyrene box to protect them against physical damage, drying-out and temperature extremes. The spat must be kept cool and shaded since exposure to sunlight causes overheating and loss of water from the shell cavity.

2. Determination of numbers, mean weight and stocking density

On receipt, the spat should be placed in the sea in trays at the appropriate density.

(a) The number and mean live weight of oysters is usually provided by the nursery, or may be obtained as follows:

(i) Weigh spat and container.
(ii) Weigh container.
(iii) Weigh and count several samples of about 500 oysters. Suitable and cheap spring balances are available. Two with capacities of 25 kg x 100 g and 1 kg x 10 g are required.
(iv) Calculate the number of oysters by:

$$\frac{\text{total weight - container weight}}{\text{weights of samples - weights of containers.}} \times \text{number in samples}$$

(v) Calculate the mean weight of oysters by:

$$\frac{\text{weight of samples - weights of containers}}{\text{number in samples.}}$$

(b) Tray stocking density can be determined as follows:

(i) From text Table 2, it can be see that the mean sea-water temperature for the Menai Strait in May is about 11°C.
(ii) From text Figure 13(b) and (d) it can be seen that the stocking weight per NWP tray for 0.15 g oysters at 11°C is about 550 to 600 g and that the number of trays required for 50,000 oysters is about twelve.

(c) The trays are now stocked at the required density and placed in the sea as soon as possible.

3. Oyster growth and further holding requirements

The ongrower may plan his further tray requirements one month ahead, by estimating the expected size which will be reached at the end of May (i.e. 0.32 g from text Figure 13(a)) and repeating the procedure in (b) above for a temperature of 14°C (i.e. expected temperature for June in Menai Strait; text Table 2).

APPENDIX 3: Explanatory leaflet on legal requirements for depositing molluscs

Control of Molluscan Shellfish Pests and Diseases

Background

This note explains the controls applied by the Molluscan Shellfish (Control of deposit) Order 1974* and the licensing arrangements. It is intended to provide helpful guidance to shellfish depositors but they should note that only the Order itself has any legal force.

The 1974 Order is designed to control the introduction and spread of molluscan shellfish pests and diseases in England and Wales (separate controls exist in Scotland). The Order divides the whole coastline of England and Wales into a number of designated areas and it is illegal to deposit in a designated area, molluscan shellfish taken from outside that area, except under licence. Decisions on the issue of licences are based on the known or believed incidence of pests and diseases in the areas where the shellfish would come from and where they would be deposited. If a proposed deposit presents an unacceptable risk of introducing or spreading molluscan shellfish pests or diseases it will normally be refused.

Deposits

"Depositing" is widely defined and means any introduction or discharge of molluscan shellfish into waters or onto land.

Designated areas

The extent of each designated area is shown on the accompanying map (see Figure A1, p. 38). Designated areas include all tidal waters within the area, the adjacent foreshore and adjacent land comprising shellfish hatcheries, pits, ponds, and cleansing or storing establishments. Only deposits in designated areas are controlled under the 1974 Order.

*SI 1974 No. 1555 as varied by the Molluscan Shellfish (Control of Deposit) (Variation) Order 1983 (SI 1983 No. 159).

These Orders was made under the Sea Fisheries (Shellfish) Act 1967 c 83.

Molluscan shellfish

The term "molluscan shellfish" is also widely defined and includes live or dead molluscan shellfish of any kind and at any stage of their development. The term also includes parts of molluscan shellfish and the shell and in this context applies to any deposit of shell including its use as cultch.

Ministry of Agriculture, Fisheries and Food
Welsh Office Agriculture Department

FIS 2A (Revised 1989) FISHERIES DIVISION 2A

The licensing system

A deposit in a designated area of molluscan shellfish (as defined) taken from outside that designated area is illegal unless it is permitted by a licence issued by the appropriate Department. Please note that all licences have conditions which, if not complied with, may lead to the licence being withdrawn, and the licensee being prosecuted.

If, after reading the following notes, you are still in any doubt about the licensing arrangements, please contact the appropriate address shown on page 42.

Do I need to apply for a deposit licence?

(a) **YES** - If the molluscan shellfish would come from outside the designated area where you plan to deposit them. This includes shellfish from abroad.

(b) **NO** -

- If the molluscan shellfish will not be deposited (as defined) in a designated area.
- If the molluscan shellfish are to be taken from, and deposited in, the same designated area.

What types of licence are there?

There are two types of licence - Ordinary and Special.

Ordinary Licences are issued to allow any number of deposits of molluscan shellfish taken from the designated areas specified in the licence. The designated areas so specified are those which have a similar or lesser recorded incidence of shellfish pests and disease as the area for deposit.

The table which shows the deposits permitted under the Ordinary Licensing arrangements (p. 43) is based on our current knowledge of the incidence of shellfish pests and disease in each of the designated areas. If new scientific information becomes available about the pest and disease status of any designated area it may be necessary to take account of this by changing the boundaries of designated areas and/or revoking and re-issuing Ordinary Licences. In any event, Ordinary Licences are only valid for a limited period and therefore need to be re-issued. **For these reasons it is important that Ordinary Licence holders comply with the condition which requires notification of any change of address.**

Requests for Ordinary Licences, indicating the number of the designated area in which deposits are proposed should be made in writing to the address shown below.

Special Licenses are required to authorise any deposit of molluscan shellfish in a designated area that is not covered under the Ordinary Licensing arrangements. This includes the deposit in a designated area of any molluscan shellfish taken from:

- outside England and Wales; or

- a designated area in England and Wales which has pests or diseases not present in, or at a higher level than, the proposed area of deposit.

A Special Licence will normally only allow one or a small number of deposits within a specified time limit. Application for a Special Licence should be made on form FIS 2 obtainable from the addresses shown below. Consideration of Special Licence applications can take some time. You should therefore apply at least 21 days before the proposed deposit is to take place and provide all the details requested on the application form. Every effort will be made to reach a decision on the issue of licences within 21 days but this cannot be guaranteed especially if enquiries have to be made.

Enquiries, advice and licensing authorities

Please contact the following addresses if you wish to apply for either an Ordinary or Special Licence or if you have any enquiries about the deposit controls and licensing arrangements:

- **For deposits in England:**
  Ministry of Agriculture, Fisheries and Food
  Fisheries Division 2A, Noble House, — Tel: (071) 238 5947
  17 Smith Square, London SW1P 3JR — Switchboard: (071) 238 3000

- **For deposits in Wales:**
  Welsh Office Agriculture Department
  Division 2B, New Crown Buildings,
  Cathays Park, Cardiff CF1 3NQ — Tel: (0222) 823567/823555

General advice, and Special Licence application forms (FIS 2) can also be obtained from the Sea Fisheries Inspectorate.

If you have any queries of a scientific nature please contact:

- Ministry of Agriculture, Fisheries and Food
  Fisheries Laboratory, Benarth Road,
  Conwy, Gwynedd LL32 8UB — Tel: (0492) 593883

The Wildlife and Countryside Act 1981

Apart from the above controls governing the deposit of molluscan shellfish, there are additional controls under the Wildlife and Countryside Act 1981 regarding the release of 'non-native' shellfish into the wild.

Under the 1981 Act is it an offence to release into the wild any 'non-native' species of molluscan shellfish unless a licence permitting the release has previously been issued by the appropriate Fisheries Department. Although it is not an offence to keep such shellfish in captivity, or in waters which are not 'the wild', it would be an offence to allow them to escape into the wild (unless it can be shown that all reasonable steps had been taken to prevent such an escape.)

'Non-native' molluscan shellfish include, amongst other species:

- Pacific oysters (Crassostrea gigas).

- Portuguese oysters (Crassostrea angulata).

- New Zealand oysters (Ostrea lutaria); and

- Manila clams (Tapes philippinarum).

Any release into the wild of these or any other 'non-native' species would need to be licensed under the 1981 Act. Please note, however, that general licences have been issued to permit all releases of Pacific oysters and Portuguese oysters into the wild and this means that it is not necessary to apply for individual licences to release these species.

Further details of the Wildlife and Countryside Act 1981 are available from:

- **For releases in England:**
  Ministry of Agriculture, Fisheries and Food
  Fisheries Division 2A, Nobel House,
  17 Smith Square, London SW1P 3JR

  Tel: (071) 238 5944. Switchboard: (071) 238 3000

- **For releases in Wales:**
  Welsh Office Agriculture Department
  Division 2B, New Crown Buildings,
  Cathays Park, Cardiff CF1 3NQ

  Tel: (0222) 823567/823555

DEPOSITS PERMITTED UNDER THE ORDINARY LICENSING ARRANGEMENTS

Area of Deposit	Areas from where Shellfish may be taken
1,3,4,5,6,19,20,21,22,23,24,25 26 or 27	1,3,5,6,19,20,21,22,23,26 and 27
2,7,10,11,12A*,12B*,13,14A,14B, 14C*,15,16,17 or 18	1,2,3,4,5,6,7,10,11,13,14A,14B,15,16,17, 18,19,20,21,22,23,24,25,26 and 27
8A*,8B*,8C* or 9	1,2,3,4,5,6,7,9,10,11,13,14A,14B,15,16, 17,18,19,20,21,22,23,24,25,26 and 27

Thus, for example, a cultivator with grounds in area 1, who holds an Ordinary Licence, will be able at any time to deposit on those grounds, molluscan shellfish taken from areas 1,3,5,6,19,20,21, 22,23,26 and 27 without further reference to the Ministry.

*Ordinary Licences which permit deposits in the Bonamia infected areas may contain additional conditions.

PLEASE NOTE:

Deposits of Manila clams (Tapes philippinarum) are not permitted under ordinary licensing arrangements. Special licences are required for this purpose.

APPENDIX 4: Specimen application form for a special licence.

Ministry of Agriculture, Fisheries and Food
Fisheries Division 2A, Nobel House,
17 Smith Square, London SW1P 3JR
☎ 01 - 238 5947. Switchboard: 01 - 238 3000

Sea Fisheries (Shellfish) Act 1967 as amended
The Molluscan Shellfish (Control of Deposit) Order 1974 as varied

Application for a special licence to deposit molluscan shellfish in designated areas

- This application should be made **at least 21 days before the proposed date of deposit.** Every effort will be made to reach a decision on the issues of the licence within 21 days but this cannot be guaranteed especially if enquiries have to be made.
- Please complete the form in **BLACK INK** and **BLOCK LETTERS** and send it to the Ministry of Agriculture, Fisheries and Food at the address given above

Part 1 – Details of the molluscan shellfish

Species

Total number or weight

Average length or weight

Source (e.g. location where shellfish would be taken from)

How are the shellfish being held at this source? *Tick appropriate box(es)*

- In a hatchery
- Above the sea bed
- In tanks (including cleansing tanks)
- On the sea bed
- In shellfish pits or ponds
- Other

If 'OTHER', please specify

Name and address of supplier

Postcode

Part 2 – Details of proposed deposit

Proposed place of deposit

How would the shellfish be held? *Tick appropriate box(es)*

- On the sea bed
- Above the sea bed
- In tanks (including cleansing tanks)
- In shellfish pits or ponds
- Other

If 'OTHER', please specify

How many deposits are proposed?

Proposed date(s) of deposit

Part 3 – Details of the applicant

Name and address

Postcode

Telephone No.

Signature

Date

Name in BLOCK LETTERS

FIS 2 (Revised 1989)

FISHERIES DIVISION 2A

For Official Use Only

Recommendation

The issue of a licence to permit the proposed deposit is:

* not recommended
* recommended
* recommended subject to the following conditions:
  * (a) that the SFI is given 10 days notice of delivery date(s);
  * (b) that the shellfish must at no time have been laid on the sea bed;
  * (c) the seed shellfish must be brine dipped according to the process outlined in the attached instructions;
  * (d) the seed shellfish shall not exceed ______ mm in dimension;
  * (e) the shellfish must be held in tanks on the hatchery site and not mixed with other stocks;
  * (f) that when no longer required adult stocks must be buried away from the sea on dry land;
  * (g) other conditions:

Delete as appropriate

Signature ______ Date ______

Grade ______

APPENDIX 5: Further reading

Bardach, J. E., Rhyther, J. H. and McLarney, W. O., 1972. Aquaculture - The Farming and Husbandry of Freshwater and Marine Organisms. Wiley-Interscience - John Wiley & Sons Inc, London and New York, 868 pp.

Briggs, R. P., 1978. Aspects of oyster culture in Strangford Lough, Northern Ireland. Aquaculture, 15: 307-318.

Davidson, P. E., 1976. Oyster fisheries of England and Wales. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, (31): 15 pp.

Drinkwater, J., 1987. Shellfish cultivation in Scotland. Scot. Fish. Inf. Pamph., (13): 20 pp.

Franklin, A., 1976. The disinfection by brine-dipping of seed oysters produced from hatcheries in *Crepidula* infected areas. Tech. Rep. MAFF Direct. Fish. Res., Lowestoft, (25): 4 pp.

Galtsoff, P. S., 1964. The American oyster, *Crassostrea virginica* Gmelin. Fish. Bull., U.S. Fish and Wildl. Serv., 64: 480 pp.

Imai, T., 1978. Aquaculture in Shallow Seas. A. A. Balkema, Rotterdam, 615 pp.

Iversen, E. S., 1976. Farming the Edge of the Sea. Fishing News (Books) Ltd., London, 301 pp.

Kafuku, T., and Ikenoue, H. (Editors), 1983. Modern methods of aquaculture in Japan. Elsevier, Amsterdam, Oxford and New York, 216 pp. (Develop. Aquacult. Fish. Sci. 11.)

Korringa, P., 1976. Farming marine organisms low in the food chain. Elsevier, Amsterdam, Oxford and New York, 264 pp. (Develop. Aquacult. Fish. Sci. 1.)

Korringa, P., 1976. Farming the cupped oysters of the genus *Crassostrea*. Elsevier, Amsterdam, Oxford and New York, 224 pp. (Develop. Aquacult. Fish. Sci. 2.)

Korringa, P., 1976. Farming the flat oysters of the genus *Ostrea*. Elsevier, Amsterdam, Oxford and New York, 238 pp. (Develop. Aquacult. Fish. Sci. 3.)

Morse, D. E., Chew, K. K., and Mann, R. (Editors), 1984. Recent innovations in cultivation of Pacific molluscs. Aquaculture, 39: 1-404.

Milne, P. H., 1972. Fish and Shellfish Farming in Coastal Waters. Fishing News (Books) Ltd., London, 209 pp.

Parsons, J., 1974. Advantages in tray cultivation of Pacific oysters (*Crassostrea gigas*) in Strangford Lough, N. Ireland. Aquaculture, 3: 221-229.

Partridge, K., 1981. A manual for Irish oyster farmers. Aquacult. Tech., Bull. Nat. Bd. Sci. Technol., Dublin 4, (1): 48 pp.

Quayle, D. B., 1988. Pacific oyster culture in British Columbia. Can. Bull. Fish. Aquat. Sci., (218): 241 pp.

Spencer, B. E., Akester, M. J. and Mayer, I., 1986. Growth and survival of seed oysters in outdoor pumped upwelling systems supplied with fertilized sea water. Aquaculture, 55: 173-189.

Walne, P. R., 1974. Culture of Bivalve Molluscs - 50 Years Experience at Conwy. Fishing News (Books) Ltd, West Byfleet, 173 pp.

Yonge, C. M., 1960. Oysters. Collins, London, 209 pp.